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The American Archaeology Division
Department of Anthropology, University of Missouri
Columbia, Missouri

Prehistoric Cultural Continuity in the Missouri Ozarks: The Truman Reservoir Mitigation Project

Volume III — Specialized Studies

Contract No. DACW41-77-C-0132

1993

By: Donna C. Roper
Principal Investigator

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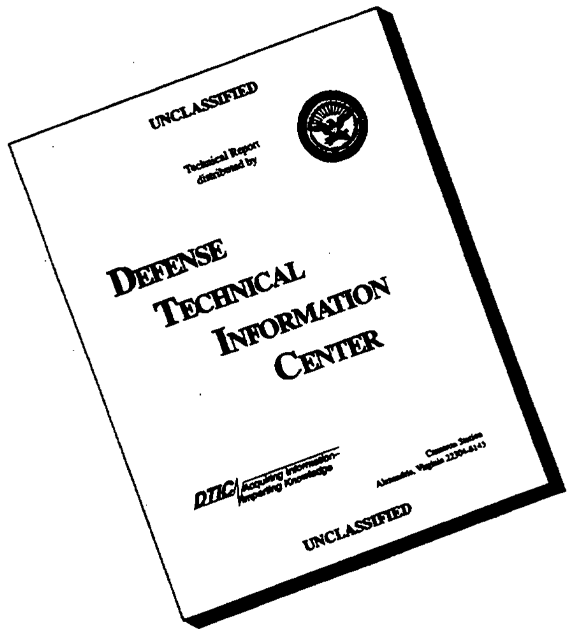

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PREHISTORIC CULTURAL CONTINUITY IN THE MISSOURI OZARKS:

THE TRUMAN RESERVOIR MITIGATION PROJECT

VOLUME III:

SPECIALIZED STUDIES

A project conducted for the
U. S. Army Corps of Engineers
Kansas City District
Under Contract DACW41-77-C-0132

by
The American Archaeology Division
Department of Anthropology
University of Missouri
Columbia, Missouri

Donna C. Roper, Principal Investigator

1993

The study performed herein by the Contractor for the Corps of Engineers was authorized by the National Historic Preservation Act of 1966, as amended, and the Archeological and Historic Preservation Act of 1974.

Funds for this investigation and report were provided by the U.S. Army Corps of Engineers. The Corps may not necessarily agree with the contents of this report in its entirety. The report reflects the professional views of the Contractor who is responsible for collection of the data, analysis, conclusions and recommendations.

The Kansas City District has delayed the publication of this report because 30 data figures and two tables were not with the camera-ready originals to be used in the printing of this document. Various sources associated with the report were contacted to obtain copies of these figures, but the figures were unattainable. The District has been able to replicate some of these figures, however, 20 figures and the two tables were not reproducible. It was decided to print the report with the data missing. Most of the figures are missing from Volume I.

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The investigations focused on : 1) the nature of prehistoric settlement systems of the Pomme de Terre river valley; 2) the relationship of the Pomme de Terre river valley to the remainder of the lake area and to western Missouri in general; and 3) the study of how human communities used their natural environment, how they dispersed themselves and their activities across the landscape and located where they did, how prehistoric people extracted energy from the natural environment, and why these patterns change.

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PART I.

MORTUARY ANALYSES

NUMBER 1.

THE MORTUARY ASSEMBLAGES IN SOUTHWEST MISSOURI: EVIDENCE FOR CONTINUITY OF A WOODLAND PATTERN

by

Susan K. Goldberg

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Several people have given assistance and support during the formulation, analyses, and writing stages of this project. I would like to extend special thanks to Sharon L. Brock who performed the analyses of skeletal remains from the sites on which this report is based. More importantly, she supplied the intense interest and interaction necessary for a conjunctive approach to this mortuary site analysis. Without her expertise and motivation, this project would have resulted in less than half of what it did. Thanks are also due to Dr. Donna C. Roper who gave generously of her time, providing much food-for-thought through hours of discussion. Her knowledge of the study area and of archeology, as well as her interest in this research, provided constant support.

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I am grateful to several people for their more specific contributions. Frances B. King identified the botanical remains; her report appears in Appendix D. Dr. Ralph M. Rowlett and Margaret D. Mandeville provided thermoluminescence dates which are in Appendix E. Chert identifications were made by Robert Skrivan. Jack H. Ray provided data on naturally occurring chert deposits. V. Ann Tippitt supplied information about the ceramic vessels and their cultural implications. Susan L. Brown drafted several of the figures. The photography for the projectile point plates was done by Rebecca A. Ketcherside. The first draft was typed by Peggy J. Loy and the final by Jean Sparks. All of these people, as well as many Truman employees and students at the University of Missouri have my gratitude for support – both direct and indirect – that they have supplied.

Extreme thanks are given to Patricia A. Oman and Sharon L. Brock for their support of a special kind – emotional – throughout the project.

CHAPTER 1

INTRODUCTION

The notions of isolation and resultant cultural conservatism and stability have been widely used to explain the archeological assemblages in the Ozark Highland. Tests of such models have been confined largely to the technological subsystem of cultural adaptation. The present study is an attempt to test this notion of cultural conservatism using a different cultural subsystem – mortuary behavior. Mortuary data were chosen because of their potential to elucidate cultural dynamics which might have occurred in non-technomic systems. Mortuary assemblages should reflect all aspects of the total system of adaptation, as they are a composite of the biological, technological, sociological, and ideological systems.

The mortuary data derive from a reanalysis of remains from fifty-four tumuli recovered during investigations in the Truman, Stockton, and Pomme de Terre reservoir areas in southwest Missouri. Two classes of data – artifacts and tumulus form and structure – are used in the present study. Skeletal remains from most of these same tumuli are being analyzed concurrently (Brock 1980).

A brief discussion of the study area is provided in Chapter 2. A basic environmental description, and a summary of the relative chronology, derived from previous research, are presented. This latter section, particularly the discussion of the Woodland and Mississippian periods, provides a background for understanding the proposed model of isolation and conservatism in the Ozarks.

Chapter 3 provides a statement of the problem orientation for the study. A summary of methodological approaches previously applied to this problem is given. The value of applying mortuary data to problems of this nature and the theoretical ramifications of such applications are discussed.

The model of cultural conservatism in the Ozark Highland is discussed and developed in Chapter 4. Possible causes and mechanisms of such cultural developments, including environmental and locational peculiarities of the region, are offered. Cleland's (1976) model of diffuse economic adaptation is posited as an explanation for the cultural patterns in the area. The implications of such a model for mortuary behavior are explored and are used to derive a set of research questions or propositions concerning the patterning of burial assemblages. These are then tested.

Chapter 5 is the first of two which present the data analyses. A factor analysis of burial inclusions is used to describe the inter-tumulus variability and patterning. From this, the cultural historical relationships between the tumuli are assessed and a seriation of tumuli is developed. Spatial patterning of the assemblages is also described. Additionally, patterns of interaction with cultural groups outside the region are identified. The results of this assemblage analysis support a model of isolation and conservatism for the region. Much of the variability is ascribed to minimal contacts with outside populations, some sub-regional clustering, and random inclusions of certain artifacts. With these exceptions, the tumulus assemblages are fairly homogeneous.

Chapter 6 examines patterns in the form and structure of the tumuli as they relate to temporal and spatial patterns discerned in the factor analysis. The only non-random pattern which emerges is the tumulus form; stone filled cairns become more prevalent in the later periods. These patterns are then related to burial structures in other regions. An explanation is offered for the development of, and changes in the mortuary patterns in southwest Missouri, viz., minimal Hopewell influence.

The final chapter provides a summary and conclusions. The proposition that the southwest Missouri population was culturally isolated is supported. The retention of a diffuse economy which was well-adapted to the specific environment is offered as an explanation for the slow rate of culture change and apparent continuity of cultural systems.

CHAPTER 2

THE STUDY AREA

The present study is concerned with archaeological mortuary materials recovered along the western edge of the Ozark Highland, in southwest Missouri. The majority of the remains were recovered from tumuli[1] in the area currently being inundated by the Harry S. Truman Reservoir. These waters will cover most of the Osage Basin between Warsaw, Missouri and the Kansas state line (Fig. 1). Other burial tumuli were recorded and excavated during investigations prior to the flooding of the Sac River by the Stockton Reservoir, in Cedar and Dade counties, Missouri, and the Pomme de Terre Reservoir area in Hickory County, Missouri (Fig. 2).

Environment

Only a brief description of the environmental setting will be presented here. For more complete summaries of floral and faunal communities, and for geological and climatological data, the reader is referred to McMillan (1971: 9-58; 1976a: 13-44).

The area lies within two major archaeological and physiographic regions of Missouri, as defined by Chapman (1975: 1-19). The Truman, Stockton and Pomme de Terre Reservoirs are near the boundary between the Western Prairie Region and the Ozark Highland Region (Fig. 1). The Ozark Highland Region is characterized by deeply incised and tightly meandering streams with steep relief along narrow valley walls. In contrast, the Western Prairie Region is characterized by less deeply entrenched streams, which have less tortuously winding meander patterns and form broader valleys with more rolling and gentle relief along the valley walls.

In general, the major vegetation of the Ozark Plateau is a deciduous oak-hickory forest (Steyermark 1963: xix) with tall-grass prairie openings. The Ozark Highland Region is dominated by oak-hickory forest with prairie in some upland openings. The Western Prairie Region was covered by tall-grass prairie, with oak-hickory gallery forests along the streams and valley walls.

A variety of fauna is present in the area now, but has changed concommitant with changes in the floral communities,

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[1]Tumuli are artificial mounds constructed over graves. The term, as used herein, describes a general class of structures which includes both rock cairns and rock and earth mounds.

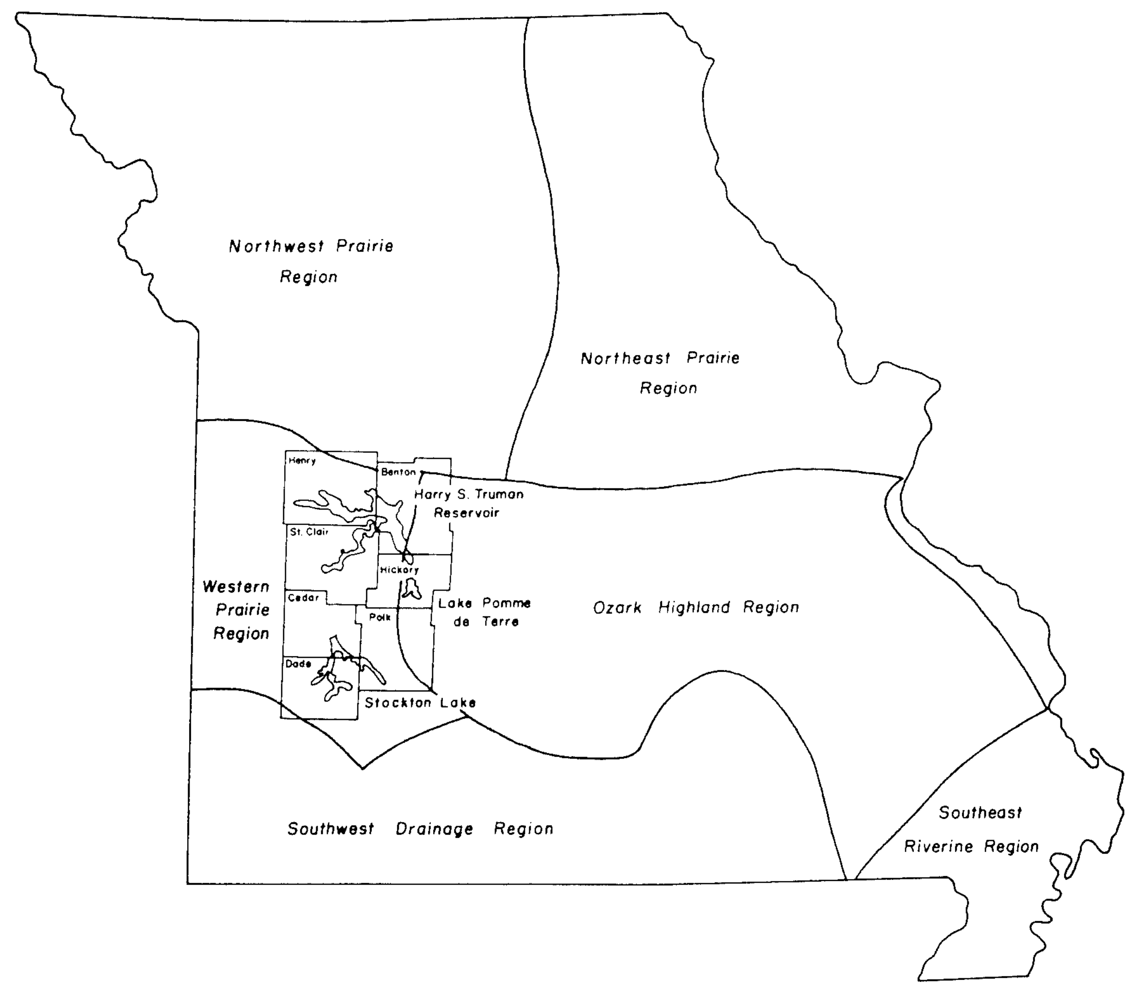

Figure 1. Relation of the study area to archeologic physiographic regions of Missouri (from Roper 1977: 12).

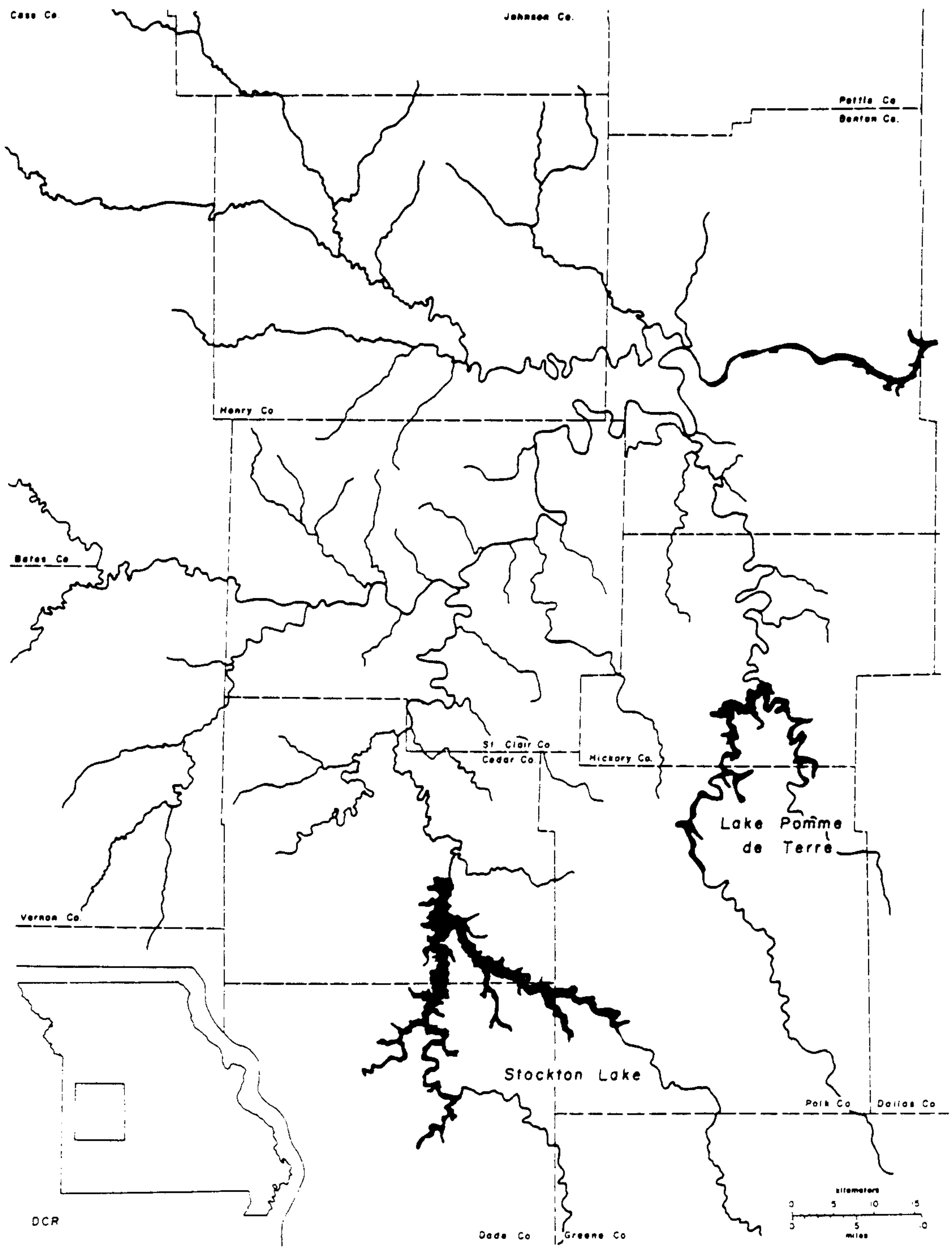

Figure 2. The study area (from Roper 1977: 17).

both prehistorically and with modern land-use practices. The most common species in archaeological assemblages are deer, squirrel, raccoon, and rabbit, as well as several species of birds, amphibians, reptiles, fish, and mussels (McMillan 1976a: 38-41). The area, being transitional between forest and grassland, is believed to be characteristic of those areas exhibiting Odum's (1971: 157) "edge effect." Ecotonal communities often support both a greater species diversity and population density than the areas surrounding it.

More detailed information on the biotic communities in the study area abounds. Discussion of the flora can be found in Steyermark (1959, 1963), Kucera (1961), McMillan (1976a), and Parmalee, et al. (1976). Information about faunal resources in the area is provided by McMillan (1976a), Schwartz and Schwartz (1959), and Parmalee et al. 1976).

Mean monthly temperatures range from 34°F. in January to 79°F. in July (McMillan 1971: 20). An average of 40 inches of precipitation falls annually, with the spring and summer being the wettest seasons. The growing season is from about April 5 to October 30, or 208 days.

Relative Chronology

The following is a brief synopsis of the culture history of southwest Missouri as it was understood when this study began in 1977. It is the result of archaeological investigations carried out since 1952 under the auspices of the National Park Service, the National Science Foundation, and the U.S. Army Corps of Engineers. This summary is by no means exhaustive, as it is meant to serve as a perspective for the present research into the cultural dynamics of the Woodland/Mississippian periods.

Perhaps the most comprehensive synthesis of Missouri archaeology is Chapman's (1975), which will be used to assign relative dates (mostly from cross-dating, as few radiometric dates are available) to the periods. Chapman's scheme is based mainly on a framework developed for the eastern United States (Griffin 1967). However, it is apparent that, particularly in the late part of the cultural sequence, by virtue of the study area's proximity to the Plains, this eastern woodlands taxonomy is not wholly adequate as an organizing framework. Perhaps more applicable would be the basic sequence outlined by Willey (1966: 315), which is based on Wedel's (1961: 280) synthesis of the Central Plains. A graphic comparison of these three different sequences (Fig. 3) was developed by Roper (1977: 14).

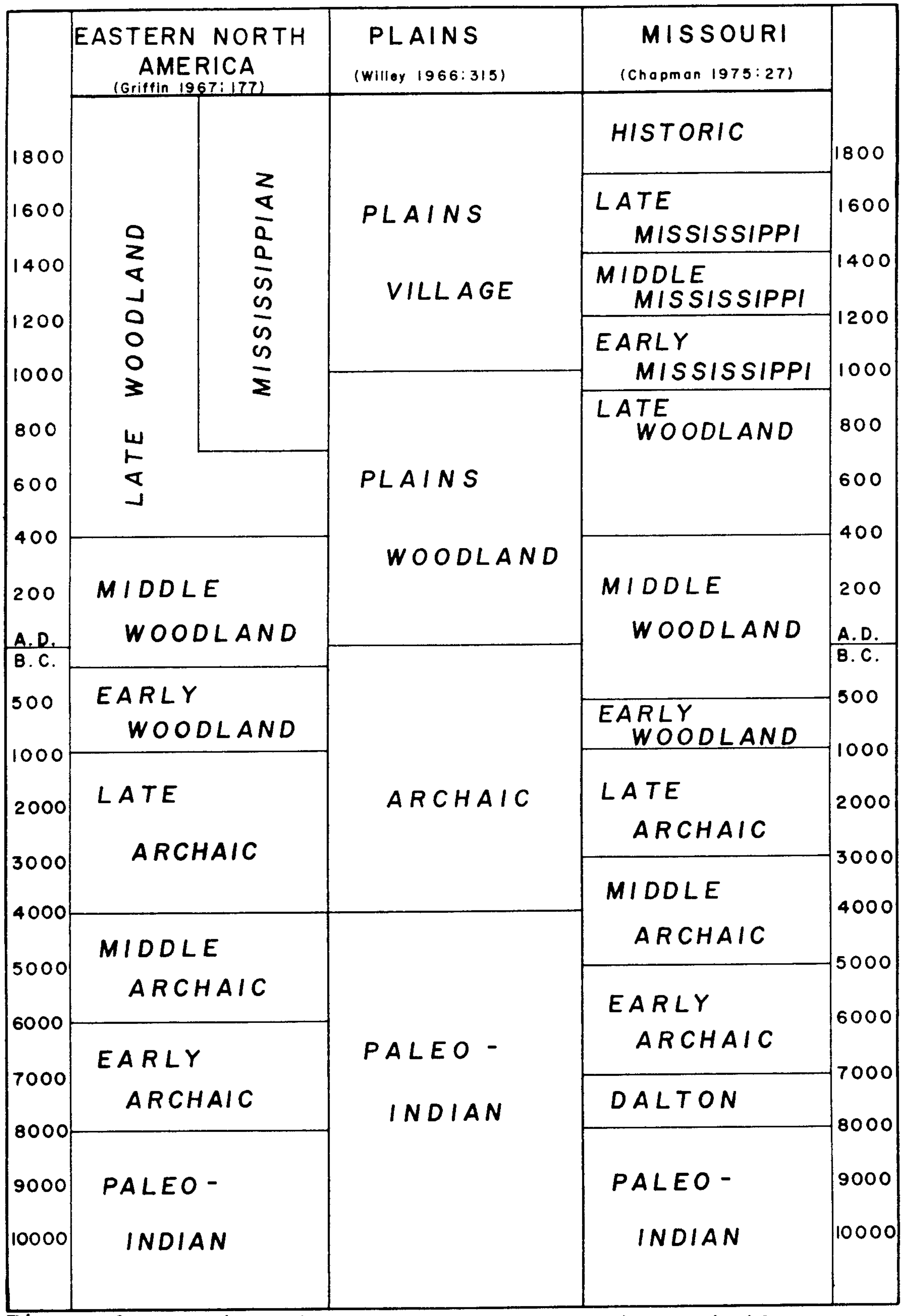

Figure 3. Basic culture sequences for Missouri (from Roper 1977: 14).

PALEO-INDIAN PERIOD (ca. 14,000-10,500 B.P.)

There is little evidence of occupation in southwest Missouri during this Early Hunter Tradition (Chapman 1975: 60) period. Finds of Folsom- and Clovis-like projectile points are rare and from the surface: six from the Western Prairie Region and one from the Ozark Highland Region (Chapman 1975: 71-73). It has yet to be determined whether so few finds are due to lack of occupation, sampling error, or sedimentation over these remains (Roper 1977: 16).

ARCHAIC PERIOD (Ca. 10,500-3,000 B.P.)

The Archaic Period, characterized by Chapman and Evans (1972: 3) as part of the Hunter-Forager Tradition, can be broken into Dalton and Early, Middle, and Late Archaic. The distinction between Dalton and Early Archaic is somewhat arbitrary, the former characterized, however, by the presence of Dalton and Plainview point types. Chapman (1975: 95-126) has placed the Dalton Period (10,500-9500 B.P.) between the Paleo-Indian and Early Archaic periods.

Like, Paleo-Indian, Dalton is poorly represented in the study area. Evidence of this occupation comes from Rodgers Shelter (23BE125) in the Pomme de Terre River Valley and the Montgomery Site (23CE261) on the Sac River, as well as from test excavations at the Hand Site (23SR569) on the Osage River. The Truman survey collections do, however, contain specimens from ten additional sites throughout the reservoir (Roper and Piontkowski 1977).

Two components attributable to an Early Archaic (post-Dalton) period have been excavated in the study area. Culture/time stratigraphic units 9, 8, and 7 a Rodgers Shelter, although assigned by McMillan (1976b: 224) to a Middle Archaic context, date to 8600-7000 B.P. The Wolf Creek Site (23SR569) on the Osage River is cross-dated to 8900-8200 B.P. on the basis of a bifurcated base point (Piontkowski 1977: 30). The remains at Rodgers are interpreted as those of a base camp, used principally for plant processing and manufacturing/maintenance of tools. The occupation at Wolf Creek may be similar to the Dalton occupation at Rodgers and elsewhere (Joyer and Roper n.d.: 9).

Evidence for Middle Archaic occupations in southwest Missouri are somewhat more abundant than for the previous periods. Culture/time stratigraphic units 5 to 9 at Rodgers Shelter are dated to 8600-6300 B.P. (McMillan 1976b), and fall within the Middle Archaic period (ca. 7000-4000 B.P.). Many other Middle Archaic components are known in the study area.

Occupations in the study area during this period must be interpreted with reference to environmental change occurring there during the mid-Holocene (ca. 5000 B.P.). During the Hypsithermal, there appears to have been a shift from a grassland/forest edge to a grassland ecotone (McMillan 1976b: 227-228). Such environmental change seems to have greatly affected occupants at Rodgers Shelter. Early in the Middle Archaic period the site was used as a base camp for processing plant materials and production and maintenance of tools. Later, there was a shift away from plant processing and a change in faunal exploitation with greater dependence on rabbits, rodents, and mussels (McMillan 1976b). The shelter was completely abandoned around 6300 B.P., attributed to continued environmental deterioration (McMillan 1971: 188).

Such environmental change did not effect total abandonment of southwest Missouri, as is evidenced by remains at Phillips Spring (23HI216) (Chamko 1976: 108). The prehistoric populations there were experimenting with squash cultigens, implying some degree of permanence of occupation.

The Late Archaic period (4000 to 3000 B.P.) in southwest Missouri sees a return to climatic conditions favoring the previous forest/prairie ecotonal environment. With this environmental shift came major changes in the occupations and adaptations within the area. Understanding the occupation and use of the area during this period is important to the present research, as many of the adaptations seen during the Late Archaic apparently continue into the later part of the archaeological sequence. Occupations during the Woodland/Mississippian periods seem to have developed from patterns which formed in response to environmental changes occurring around 4000 B.P.

The Late Archaic is recognized by a variety of point types: Afton, Smith Basal-Notched, Etley, Nebo Hill, Sedalia, and perhaps Cupp and Table Rock Stemmed (Joyer and Roper n.d.). Components of this period have been identified throughout the area, in the Pomme de Terre basin (Chapman 1954, Wood 1961), Truman Reservoir (Roper 1977: 27-29), Table Rock Reservoir (Chapman 1956), and northeast Oklahoma (Baerreis 1951; Purrington 1971). These occur in shelters such as Rodgers Shelter (McMillan 1976b: 200), Blackwell Cave (Falk 1969; Wood 1961), Griffin Shelter (McMillan 1966), Saba Shelter (Vehik 1976), as well as St. Clair County (Chapman 1975: 186-190) and Stockton Lake (McMillan 1968a: 7). Late Archaic components are also prevalent in open sites in the area. Two components have been identified at Phillips Spring, dating from 3050 to 2910 B.P. and from 2340 to 1990 B.P. (Chomko 1976: 1). The Merideath Site (23SR129) (Falk 1969: 7-39) and the Thurman Site (23HE151) (Falk and Lippincott 1974), which has pit features and post molds, both contain Late Archaic components.

Both Rodgers Shelter and Phillips Spring were occupied intensively during this period. Rodgers functioned as a base camp with hunting, generalized and specialized cutting, handstone pitting, and ritual/ceremonial activities taking place. Gathering and deer hunting again became the major subsistence activities (McMillan 1976b: 220), with an overall increase in diversity of utilized species.

The major hallmark of change from the Middle to the Late Archaic is in tool diversity. Several explanations for the increasing variety of tools have been offered by Joyer and Roper (n.d.: 14-15). Their first explanation is regional differentiation, and presumably cultural isolation. They argue that prior to the Late Archaic, the study area was a marginal expression of southeastern United States cultural complexes. With the Late Archaic, populations in southwest Missouri interacted in some way with complexes in the lower Missouri and central Mississippi River drainages. A second explanation is that the diversity of tool forms represents temporal differentiation, although Joyer and Roper suggest that such an explanation will probably not account for all of the variability. A third explanation, that of functional variability has been examined by Nicholas (1978). He has tentatively shown that, although several Late Archaic point styles do exhibit some different patterns of usage, all were multi-purpose cutting tools. He suggests that the different styles merely represent a cultural cline along an ecotonal environment which necessitates the use of tools with similar functions.

Diversity similar to that seen in tool forms in the Late Archaic is also apparent in the settlement systems. Not only are these sites located in a greater variety of places, but size and density of debris scatters are more variable.

Important to the present study is the fact that it is during the Late Archaic that we may have the first evidence for burial in tumuli. Afton points, a form found in Blackwell Cave and at the Afton Spring in Oklahoma (Wood 1961: 88-90), as well as in several open sites in southwest Missouri (Roper 1977), was the major artifact form recovered from the Holbert Bridge Mound (23HI135). Colline Mound (23PO305) in Stockton Reservoir also contained Afton points. Radiocarbon dates from Blackwell Cave (1150 ± 85 and 750 ± 150 B.C.) indicate that the Afton complex ranges between 3100 and 2700 B.P. (Falk 1969: 86).

Late Archaic occupations, as suggested by Falk (1969: 89), are longer or larger than in preceding periods. Based on faunal and artifactual debris, it appears that there is more regular, seasonal exploitation of local resources.

Additionally, there is more diversity in the settlement patterns and in tool styles (Joyer and Roper n.d.). There is also evidence from Rodgers Shelter (McMillan 1976b) and two burial tumuli that ceremonial activities were important to Late Archaic populations in southwest Missouri.

WOODLAND PERIOD (ca. 3000-700 B.P.)

The Woodland period, generally characterized by the first introduction of pottery, evidence of horticulture, and a developed burial complex (cf. Willey 1966) might also be divided into Early, Middle, and Late. These terms, as used here, denote units of time, or periods. Such a subdivision appears to be useful in southwest Missouri, mainly as an analytic referrent. While the Ozark Highland was occupied continuously throughout these three time periods, there is little archaeological evidence to show that there were internal cultural changes that would necessitate the use of separate taxonomic units. Such cultural changes were occurring elsewhere, however. The retention of the Early, Middle, and Late designations allows comparisons between southwest Missouri and these other areas. There is scant evidence in southwest Missouri of an identifiable Early Woodland horizon. In fact, it is interesting to note that in many of the shelters and open sites in the area, excavations often reveal what has been labeled a Late Archaic/Woodland component. It has yet to be determined whether these deposits, where artifacts typical of both periods are found, are the result of post depositional mixing, or of cultural change, with the addition of new technologies to pre-existing assemblages. There is some evidence here, as elsewhere in the Eastern Woodlands, to suggest that cultural adaptations remained basically unchanged at this time, even though pottery found its way into the cultural inventory. Thus, taxonomies which include a major break between the Late Archaic and the Early Woodland may be artifically conceived and inappropriate in southwest Missouri.

The Early Woodland period has been dated to about 3000-2300 B.P. One component in the Ozark Highland, at Boney Spring, has been assigned to this period (King and McMillan 1975, Bass and McMillan 1973), but radiocarbon dates of 1900 $\pm$ 80, 1910 $\pm$ 80, and 1920 $\pm$ 50 B.P., or about A.D. 50 (Wood 1976a: 102) cast doubt on this assessment. Limestone- and sand-tempered pottery, as well as a variety of corner-notched dart points and a generalized lithic assemblage (Wood 1976a: 102) would seemingly place the component in a Middle Woodland context.

Middle Woodland components are somewhat more prevalent in the area than are putative Early Woodland sites. However,

the quantity of diagnostic Middle Woodland artifacts appears to be small. This situation may result from small or ephemeral occupations or be due to the lack of adequate research designs (Wood 1961: 103). The later of these alternative explanations may be the best. Since the horizon markers often used to identify Middle Woodland components in areas outside southwest Missouri (e.g. Classic Hopewellian traits) may function principally in a social interaction network (Struever and Houart 1972), they might be expected to be absent, or at least minimal, in areas such as southwest Missouri which are geographically or culturally isolated from the exchange system. So the fact that Hopewellian goods are not found in abundance in the study area does not necessarily preclude the presence of a fairly major occupation in southwest Missouri during the same time. A similar situation seems to be present in northeast Oklahoma, as evidenced by the assemblages at the Cooper sites (Purrington 1971). Here, there seems to be a Hopewellian occupation, perhaps related to Kansas City Hopewell sites. There is an abundance of corner-notched Cooper points which are similar in form to the Snyders and Gibson forms from Hopewellian contexts further north. These and Hopewellian pottery forms are found exclusive of the more exotic Hopewellian artifact forms. Thus, there may be an indigenous Middle Woodland culture in southwest Missouri, exclusive of, in addition to, or interacting with and influenced by, Middle Woodland cultures from outside the area.

Middle Woodland components have been found at Rodgers Shelter in Stratum IV (McMillan 1971: 189), Blackwell Cave, Stratum IV (Wood 1961: 103) and Soledad Shelter (Wood and Pangborn 1968b: 2-7). These components have usually been assigned on the basis of rocker-stamped and roulette-impressed pottery, but other artifact types such as cut wolf maxillae, a shale "mammiform" object, and Snyders points have been found in tumuli of the Fristoe Burial Complex (Wood 1961: 105-106) and are indicative of Hopewellian influence.

The Late Woodland period is dated at 1500-1000 B.P. in Missouri (Chapman 1975: 30), but here again there may be a problem in applying a taxonomy, developed for the Midwest at large, to the specific study area. There are many indications that the Late Woodland cultural pattern lasted well into and continued perhaps contemporaneously with the Mississippian period or culture. Late Woodland components may have lasted until 700 or 800 B.P. Such is the case in the development of the Late Woodland in Illinois (Moreau 1973), the Cache basin in northeast Arkansas (House 1975), and in northeast Oklahoma (Purrington 1971). There appears to be a cultural lag or persistence of a cultural tradition into a later period, with the Late Woodland adaptations and technologies remaining basically unchanged by direct contact with Mississippian cultures.

The Late Woodland components in southwest Missouri are characterized by limestone-, sand-, and grit-tempered pottery, as well as by Scallorn, Young, and Rice Side-notched points. The Mississippian cultural indicators are shell-tempered pottery and triangular (notched or unnotched) arrowpoints. These external horizon markers are found intermixed in excavations from several shelters and open sites, as well as in surface survey collections from southwest Missouri. Three possible explanations for this mixing are offered by Vehik (1978: 22): (1) inadequate excavation technique resulting in obscuring separation of horizons; (2) Mississippian use of sites formerly occupied by Late Woodland populations; (3) continuation of a Late Woodland cultural adaptation into the Mississippian period, with contact between southwest Missouri populations and Mississippian villages outside the Ozark Highland. Although neither of the first two possibilities can be adequately tested, neither seems to be valid. First, the sites were excavated by different personnel at different times, so it seems unlikely that, if the horizons were readily discernible, no one was able to separate the components. Secondly, there appears to be too much mixing throughout all depths in the sites to assume that the Late Woodland and Mississippian artifact types were deposited sequentially rather during the same period. "Therefore, it seems the third proposition that Late Woodland populations were an isolated group during part of the Mississippian period in the Ozark Highland is the most economical way to explain the intermixture of Late Woodland and Mississippian-like artifacts in many of the most recent components in southwest Missouri" (Vehik 1978: 26).

The presence of a few Mississippian artifacts in seemingly Late Woodland components is common throughout the Ozark Highland; in the western part there may have been contact with Kansas City Mississippian populations (Wood 1961: 107); in the central (Chapman and Chapman 1964: 54) and northeast (McMillan 1965b: 77) areas, with Cahokia-St. Louis Mississippians.

In the past, Wood (1961: 104-110) attempted to order ceramic complexes from the Pomme de Terre River basin, defining several taxonomic units. The "Lindley Focus" was based on several open sites as well as Component D at Blackwell Cave. He originally included this focus with the Fristoe Burial Complex in the Highland Aspect. Following the "Lindley Focus," which was characterized by limestone-tempered pottery, Gary, Langtry, Rice side-notched, and corner-notched dart forms, with a variety of notched and unnotched arrowpoints, was the "Nemo Complex," which also included arrowpoints and Rice Side-Notched darts, but which had shell-tempered pottery. The "Nemo Complex" was based on Blackwell Component E. More

recently Wood (1967: 105) has regarded the Fristoe Burial Complex as an independent unit, but has discouraged the use of "Lindley Focus" and "Nemo Complex" as taxonomic units, and they have dropped from the literature.

Further south, in the Stockton Reservoir, are a number of tumuli which share a variety of traits with the Fristoe Burial Complex. However, they differ by virtue of some artifacts, such as large amounts of bone tools, Cupp points, and vegetal remains (Wood 1965). No taxonomic units have been devised for these tumuli.

It appears then that there is some, at least superficial variability, either in time or space. Such variability may, in fact, be confined to burial patterning. However, there seems to be a generalized Woodland pattern in the southwest Missouri Ozarks. Definitive artifact types include limestone-, grit-, grog-, or sand-tempered pottery and Rice Side-Notched, Scallorn, and Young points. Other characteristic artifacts are bone pins, awls, and punches, shell beads, antler flaking tools, metates, manos, anvils, hammerstones, and hematite, as well as the more generalized oval and triangular bifaces, oval and end scrapers, drills, projective points of several varieties, and cores and flakes.

Another characteristic of the Woodland period in southwest Missouri is that there is evidence of structures from at least two sites. Dryocopus Village, 23CE120, on the Little Sac River contained four circular to oval houses, with diameters of 13, 18, 14, and 13 feet (Calabrese *et al*. 1969). Flycatcher Village, 23CE153, on the Sac River, has at least three houses with similar architecture. There were no central posts or internal fireplaces, suggesting that activity areas were outside the houses. Two dates of 1235 ± 95 and 650 ± 100 B.P. from Flycatcher (Calabrese *et al*. 1969: 39) are inconsistent, but the later compares favorably to the 465 ± 100 B.P. (Calabrese *et al*. 1969: 39) date from Dryocopus.

Late Woodland adaptations in southwest Missouri, based on evidence from lithic and faunal assemblages and notable absence of remains from horitucultural activity, were based primarily on hunting and gathering. At Phillips Spring, however, cultigens (squash) were present during the Archaic period, and in the Stockton Reservoir several burial tumuli contained corn. The latter populations may have been growing or somehow acquiring corn, but there is little evidence to presume that horticulture was ever a major subsistence activity.

Vehik believes that population aggregates were small and scattered, basing his postulate on a lack of substantial Late

Woodland Villages and an estimated population size (Pangborn et al. 1967: 72) of between 20 and 35 people at each the Flycatcher and Dryocopus Villages (Vehik 1978: 38). McMillan (1976b: 226) interprets the final occupation at Rodgers Shelter (C/t.s.u. 1 and upper 2) as a transient settlement station for hunting of deer and turkey, and perhaps fishing and mussel collecting. However, there is evidence accumulating now in Truman Reservoir (albeit from surface survey data) that Woodland occupation, particularly in the river bottoms, was extensive (D.C. Roper, personal communication). Whether these nearly continuous scatters of lithic debris, which contain Woodland artifacts, are indicative of a number of occupations over a long period and/or intensive use must await analysis of excavated materials and radiometric determinations. House structures occur rarely in Woodland sites, but this cannot be used as a reliable indicator of size or intensity of occupation of sites, as poor preservation of such features appears to be the rule in southwest Missouri.

CHAPTER 3

PROBLEM ORIENTATION

The objective of the present study is to identify and describe the patterning and variability in one part of the archeological record of southwest Missouri; viz., the burial tumuli. These data will then be used in an attempt to explain some of the cultural dynamics of the populations in the Ozark Highland during the Woodland period.

Previous Approaches

In the past, a number of researchers have characterized the prehistoric cultures in the Ozark Highland as marginal, conservative, and stable. They suggest that although the Ozark populations were spatially close to eastern Woodland and Mississippian cultural developments, they were not greatly influenced by them (Willey and Phillips 1958: 124-125; Willey 1966: 250; Chapman 1952; Wood 1961: 118, 1967: 126). Baerreis (1951: 1) noted that the area supported only a small population and has expressed the notion that parts of the Ozarks may have been marginal areas in which complexes of an earlier stage persisted with, and only gradually adopted innovations from, cultural complexes characteristic of later periods (Baerreis 1959: 271).

Until recently, the framework and goals of archeological research have not supported systematic investigations of such questions about the cultural dynamics of prehistoric populations. However, with the current emphasis in archeology on describing, understanding and explaining the variability in the record (e.g., Binford 1972; Hill 1970; Schiffer 1976), have come more systematic attempts to understand cultural processes. Such has been the trend in much of the archeological research in the Ozarks in the last ten years.

One such study (Purrington 1971) involved a reanalysis of materials from Delaware County, Oklahoma, on the western periphery of the Ozark Highland. Purrington presented a wealth of data supporting the notion that prehistoric populations in northeastern Oklahoma were culturally stable and conservative. However, he did little to explain such stability and conservatism.

More recently, Vehik (1978) tested several hypotheses ultimately derived from Cleland's (1976) focal-diffuse model of adaptation. Operating under the assumptions that southwestern Missouri populations were indeed culturally stable

and conservative and adapted by means of a diffuse economic strategy, he tested hypotheses concerning the variability between sites assigned to the same Late Woodland cultural unit. The patterning of the variability was attributed to variability in site function, as would be expected to occur within Cleland's model (1976: 65).

Unfortunately, Vehik's (1978) work was not intended to specifically test the notion of conservatism and stability, nor did it adequately account for variability within the Late Woodland period in southwest Missouri which might be expressed in other than a technomic context. That is, although all populations may have been similarly adapted to an environment, an analysis which is limited to the technomic level of socio-cultural integration may tend to minimize variability in the sociotechnic and ideotechnic levels (Binford 1962).

In order to adequately test the widely held notion that prehistoric populations in the Ozark Highland were culturally conservative and stable, and to explain such stability, all aspects of the total system of adaptation must be examined; biological, technomic, sociological, and ideological levels of integration.

The Use of Mortuary Data

For its potential in elucidating cultural dynamics of the Ozarks population(s) one cultural subsystem, mortuary behavior, was chosen for the present analysis. This particular subsystem was selected for two major sets of reasons: one being strictly pragmatic and the second, scientific.

In southwest Missouri a combination of processes operate to leave a poorly formed and poorly preserved archeological record. Geomorphic processes serve to mix cultural sequences; sedimentation rates in the past few millennia have often been slow and surfaces are often deflated. Additionally, sites in the region, by virtue of their being shallow, are severely damaged by current agricultural practices and indiscriminant digging by amateurs. Burial tumuli, although often looted, were formed almost exclusively by human manufacture, so are little affected by sedimentation processes. Since they are located exclusively on bluff or ridge tops, plowing has had no effect on them. All in all, these tumuli probably represent the best preserved part of the archeological record in southwest Missouri.

Due to these peculiarities of formation processes, and to the goals of archeological research in the past two decades, data from burial tumuli are well represented in the collections from the Missouri Ozarks. Many mounds and cairns

were recorded and excavated during investigations in the Pomme de Terre, Stockton, and Truman (Kaysinger Bluff) reservoir areas. The collections from several of these are large and usually from complete excavations. The collections, therefore, have the potential for supplying a wealth of data for mortuary behavior analysis.

Several of these tumuli have been published, most notably by Wood (1961, 1967). These reports tend to be descriptive and taxonomic in nature, and fully describe only the artifacts. Little analysis was done on the skeletal materials, a major component of any mortuary site.

Given the advances which have been made in theory and method in both archeology and bioanthropology in the past decade, a reanalysis of these tumulus materials is warranted. Although mortuary data cannot yield a complete record of a cultural system, this one subsystem is an especially valuable one. It is, in some ways, a composite of four levels of cultural integration – biological, technomic, sociological, and ideological.

From a biological standpoint, the tumuli in southwest Missouri offer data which are unavailable from other types of sites. With the exception of a few skeletal remains from shelter and spring sites, all of the data necessary for a biological analysis of southwest Missouri populations are those derivable from the skeletal remains in the tumuli.

A series of skeletal analyses will be invaluable for ascertaining patterns of cultural and biological adaptation. We should be able to identify effects of the physical environment on the local populations and investigate the role of cultural factors in altering this effective environment. Studies of gross osteology, dentition (e.g., Scott 1974), trace elements (e.g., Gilbert 1977), and histomorphometrics (e.g., Stout and Simmons 1979) should reveal physical and dietary factors in adaptation. When these are combined with demographic, epidemiological and pathological studies, we can begin to identify the role of cultural intervention on physical adaptation. Additionally, through the use of nonmetric and metric traits, a measure may be made of biological distance (degree of genetic affiliation) (e.g., Buikstra 1972). From this, some social relationships such as status and residence patterns may be inferred (e.g., Lane and Sublett 1971). Thus, from the skeletal remains we can begin to answer questions about diet, crowding, disease transmission, in-breeding, social status, and residence patterns. These skeletal analyses are being investigated concurrently by Brock (1980).

Burial site data also lend themselves to analyses of social interaction, primarily due to the special functioning

of mortuary practices in a cultural system. Mortuary activities, more so than subsistence and other technological activities, tend to reflect social and ideological relationships, both within a population and with other populations. This reflection is due to the fact that the social interactions which were in operation before a person's death are formally legitimized at death. An individual's social persona is symbolized at death; processes of disposal being indicators of the composite of an individual's social identities (Saxe 1970: 7). Thus, an analysis of patterns of disposal of the dead should reflect the social structure and interactions of the living.

The conceptual framework underlying most current analyses of mortuary data is based on work by Saxe (1970), which in turn is based on elements from Goodenough's (1965) anthropological role theory. Several anthropologists have lent credence to its use through ethnographic confirmation (Tainter 1975; Goldstein 1976; Vehik 1975), but perhaps the most convincing of the studies is that by Binford (1971). Using extensive ethnographic literature Binford tests the following propositions: (1) "there should be a high degree of isomorphism between (a) the complexity of the status structure in a socio-cultural system and (b) the complexity of mortuary ceremonialism as regards differentiated treatment of persons occupying different status positions" and (2) "there should be a strong correspondence between the nature of the dimensional characteristics serving as the basis for differential mortuary treatment and the expected criteria employed for status differentiation among societies arranged on a scale from simple to complex" (1971: 18-19). In spite of some operational difficulties, the propositions were upheld.

Ucko (1969) has urged that archeologists be cautious in using such general models of social structuring in interpretation of mortuary practices. He presents several cases from the ethnographic record of unique mortuary behavior which, if interpreted as being the normal mortuary behavior, would lead to spurious conclusions. This would seem to be a sampling problem and not unlike archeological interpretations of other cultural domains. To model past societies we must describe the variability as fully as possible and then discern the patterns within each dimension.

Several archeologists and bioanthropologists have successfully used archeological mortuary data to infer social patterning and structure. The basic tenet underlying most of the analyses has been the same; individuals of different status will be accorded different burial treatment. Several approaches have been used to discern these differences, with the approaches varying mainly in types of data used.

A major emphasis in the past has been in using primarily mortuary associations to infer status, normally attributing status to individuals on the basis of frequency and type of burial accoutrements (e.g., Stickel 1968; Peebles 1971; Rathje 1970, 1973; Winters 1968; Larson 1971). Tainter (1978) described an ethnographic survey where material inclusions were used to symbolize status at death in less than 5% of 93 cases. The dependence archeologists have on artifactual associations as the sole basis for social inference seems inappropriate.

The addition of other forms of mortuary data to the basic grave associations is necessary if we are to discern the full extent of symboling in any given prehistoric mortuary event. Such a tenet follows from Saxe's (1970) propositions and the patterning to be found in the ethnographic record. The goal should be to discern any and all variability which distinguishes between individuals. All stages of the mortuary ritual should be included; from post-mortem body preparation (e.g., Buikstra 1972; Brown 1971) to actual burial form and location (e.g., Peebles 1971). All events which indicate some degree of energy expenditure afforded to an individual might be used to infer conference of status (Tainter 1975).

While it is apparent that a major contribution in analyzing mortuary data is in the realm of testing hypotheses about social status and complexity, reference dimensions from which to frame hypotheses and base analyses must first be developed. Without temporal or spatial dimensions as a basis, archeological mortuary data cannot be used effectively to talk about differential and changing adaptation. This point is often glossed over in regions where mortuary studies abound (e.g., the Illinois and Mississippi River Valley, California) and not surprisingly. It is these areas where there are longstanding, well-dated culture histories developed through decades of collection, excavation and research. In these areas, the resource bases are well-known and practitioners of mortuary analysis, therefore, have quite a leg to stand on.

Unfortunately, this depth of knowledge does not prevail for the Ozarks region. This is due to formation processes which tend to obscure the record and to the relative youth of archeological investigations in the area. There are few radiocarbon dates from the tumuli in southwest Missouri and very little systematic analysis of the range and patterning of the variability of their contents and form. Thus, any attempt, at this point, to determine status relationships on a site by site level would be meaningless. Not only are the samples from each tumulus small and artifactual associations unclear, but we know little about cultural relationships in the system to which they belong.

Mortuary site assemblages, analysed at an intersite level, however, are of value. The patterning of the variability among three classes of mortuary data can be used to test propositions about cultural isolation and continuity in the southwest Missouri Ozarks; artifacts, tumulus form and structure, and osteological remains. If the populations living in southwest Missouri during the Woodland/Mississippian period were indigenous, isolated, and conservative, certain patterns of integration should occur, be manifest in the mortuary domain, and appear in the archeological record. A test of such expectations, primarily in a culture-historical framework, should lend much to the understanding of the variability to be found in both mortuary and subsistence-settlement contexts.

It is to these questions of isolation and conservatism, and the ways in which mortuary site data will be used to help answer these questions, that now we turn.

CHAPTER 4

THE IMPLICATIONS OF ISOLATION AND CONSERVATISM FOR MORTUARY ASSEMBLAGES

This chapter will briefly explore some of the possible causes and mechanisms of the development of the postulated isolation and conservatism in southwest Missouri. It is only within such a framework that we can posit expectations for patterning in the archeological record. From this general discussion of patterns of adaptation which may have been operating in the past, and their archeological implications, we can identify those areas of inquiry in which an analysis of mortuary data will be useful.

Understanding the cultural dynamics in southwest Missouri seems to be a question of the types and degree of interaction among populations living in the region and between these populations and populations in regional centers outside the area. To determine whether we are dealing with an isolated, conservative population, the degree and type of interaction with other cultural regions, and the reasons for the formation of such cultural adaptations, we must examine the cultural system in the context of both the physical and social environments. We must examine the historical context in which it came to be, as well as the environmental limitations which may have necessitated it, or environmental potentials which may have allowed it. For a system to have become isolated and have its isolation maintained, it must, in some way, be bounded. This circumscription may be physiographic or cultural, or perhaps a combination of both (Carniero 1972). The explanation usually offered for the isolation of Ozark populations is physiographic. Travel through the region would have been difficult and undesirable due to meandering, unnavigable streams, and heavy underbrush.

Perhaps one key to understanding the isolation is to examine the environment. Southwest Missouri possesses a unique distribution of both prairie and forest vegetation. This fairly undifferentiated mosaic, combined with narrow stream valleys, limiting the potential for horticultural activities, may not compare favorably to surrounding areas which have more linear zones in which vegetation is concentrated. Although it is a common notion that ecotonal environments support a large diversity of species, and often in concentration, such an environment may pose limitations in terms of procurement selection and scheduling. Other potentially limiting factors must also be accounted for, e.g., water, shelter, soils, and wood.

There do, however, appear to be factors which might limit the isolation of southwest Missouri populations. Environmentally, the ecotone's unique distribution of resources could make procurement of selected species, e.g., deer, easier. There are also a number of lithic resources, such as lead, galena, and certain types of chert which are not readily available outside southwest Missouri. Additionally, there is the fact that southwest Missouri is centrally located between regional cultural centers such as those in Illinois, Arkansas, Kansas, and the Missouri and Mississippi rivers, making it a likely place for contact and trade.

Archeologically, there should be several manifestations if such isolation were effected. A full seasonal round should be represented, with faunal and botanical remains from species which could have supported a population all year. There should be either many sites, or intensively used sites with tool assemblages representative of all of the various extractive and maintenance activities necessary to support a full lifeway. This would include both habitations and storage facilities. Additionally, tool-types should be functionally suited to tasks made necessary by the specific environment in southwest Missouri.

If the population was culturally isolated, a total biological population should be represented, including young, old, sick, healthy, female and male individuals. This isolation should also be manifest in the tool forms. We might expect tools which are stylistically, if not functionally, unique to the area. Artifacts, which may have been traded in, left by intruders, or modeled after types from other areas might tend to occur out of their technomic contexts (i.e., in situations functionally different from their original intended function) (Binford 1962).

More specifically, we can derive a number of expectations of how isolation might be manifest within the domain of mortuary behavior of southwest Missouri populations. If the population(s) were isolated, and such isolation began prior to the Woodland period, we would expect antecedents of both the tumuli and the inclusive artifacts to be found within the area during the Archaic period. If, however, such isolation were effected at a later time, the structures, although perhaps not the artifacts, should appear outside the area and somewhat earlier. Such would be the case if the idea of mound building came to the Ozarks populations, independent of population intrusion.

If the notion of mound building were borrowed, we would still expect several aspects of mortuary behavior (e.g., social structure and artifact inclusions) to be unique to the area and in a form much the same as before the borrowing.

If only the notion of mound building were borrowed, we would expect many of the artifacts from mortuary contexts to be similar to those found in habitation/procurement sites. Indeed, if this is not the case, any attempts to use these mortuary data as indicators of cultural patterning of indigenous populations would be invalid. A test of the association between mortuary sites and habitation or other activity sites is a necessity. Such association can be tested only indirectly through comparison of tool-types from different site types. Thus, assuming that the tumuli were built by, and include individuals from, the population(s) responsible for the formation of these other sites may require a giant leap of faith.

There is another bias in using mortuary site data as indicators of cultural patterning. Since they are very specific functional sites, they are poor indicators of adaptation at the technomic level. Many of the same artifact types used in a technomic context may appear in a mortuary context. Others may not. Moreover, as a large degree of energy is often expended in this mode of conferring status, artifact styles and care in manufacture may differ radically from those artifacts which function as tools. Also, the number and types of exotic artifacts found in mortuary assemblages may not be representative of those found in other contexts.

While assemblages of artifacts from burial tumuli may not be good indicators of cultural patterning at a technomic level, they may be the most useful for measuring the relationship of southwest Missouri populations to surrounding populations. The definition and description of other regional complexes have often been based on mortuary practices and types of grave goods. This mortuary dimension seems appropriate, then, for direct comparisons between cultural complexes. Additionally, remains from these special purpose burial sites may show a greater range of exotic artifact types, since status is often conferred via burial goods. Since obtaining exotic goods often represents a large degree of energy expenditure, they will tend to be curated and used at the time of burial for symbolizing status, and will only infrequently occur in habitation site debris. Analysis of these exotic types may indicate the degree and perhaps the type of interaction with outside populations.

Given an effective isolation of the Ozarks populations and yet some potential for contact, and given the desirability of some Ozarks resources, as well as its location between other centers of cultural development, we might expect a trade relationship to exist with outside populations. If such a relationship existed, even minimally, we should see a small percentage of exotic goods in southwest Missouri

assemblages. Moreover, given the high degree of energy expenditure involved in acquiring such items, relative to other indigenous materials, they might tend to occur more frequently in the tumuli than in other contexts. Their elevated value would cause them to function in a non-technomic sense (Binford 1962).

If this relationship with outside populations was strictly for purposes of material distribution, and not founded in social interaction or previous cultural association, there should be minimal patterning to the distribution of exotic goods in the archeological record. The exotic goods deposited in any component may have come from several different outside sources in any number of combinations. For example, artifacts typical of various late traditions, such as Plains Village, Mississippian, and Caddo, may be found together in single assemblages in southwest Missouri, no attempt being made by indigenous populations to maintain cultural associations with any one outside group, exclusively. The areas from which the exotic goods came may also have changed through time. In other words, if acquisition of exotic goods resulted from a purely economic system, the partner(s) in trade may have been numerous and varied.

Given that the prehistoric inhabitants of the Ozarks were culturally and/or geographically circumscribed, we must ask what the consequences of such isolation would be. What types of interactions might occur during a protracted isolation?

Given an ecotonal environment and the total dependence on that environment for subsistence spelled out by isolation, we would expect what Cleland (1976) calls a diffuse adaptation, based on the scheduled utilization of several plant and animal species. The key to success, here, is the movement between resources at scheduled intervals during the year.

Settlement systems, as well as group composition, are somewhat determined by the exigencies of subsistence getting. Many environments which require a diffuse adaptation contain resources which occur in great enough abundance, and with enough predictability, that mobility is compatible with site permanence and population aggregation. Subsistence activities originate from a fairly permanent base settlement, with particular segments of the population dispersing at scheduled times for the purpose of resource procurement.

The distribution and abundance of the resources in the Ozarks would appear to limit such site permanence and group aggregation. The Ozarks, like the Prairie Peninsula – from whence Cleland's model of diffuse adaptation was derived – contain a great diversity of resources. However, the

distribution and abundance of these resources is different in the two areas. Most settlements in the Prairie Peninsula are in major river valleys where vegetational zones tend to be in a banded distribution. In the Ozarks, the vegetation occurs in a mosaic pattern. Resources within the region are less concentrated and are also less abundant per unit of area (Roper 1978). Such an environment would necessitate a high degree of mobility. Low resource density would necessitate frequent movement, possibly to quite some distance. Therefore, very small (perhaps extended family units) flexible groups would be at a premium (cf. Wilmsen 1973).

Such mobility is not inconsistent with the necessity to tend or harvest crops. From his ethnohistoric investigations, Chapman (1959) characterizes the historic inhabitants of the Ozarks region, the Osage, as primarily hunters. However, although procurement of deer and bison was a focus, they gathered wild plant species, and also planted corn. These horticultural practices did not substantially alter their semi-transient pattern of settlement. Similarly, it has been hypothesized by Struever (1968, 1971) that the inhabitants of the Illinois River Valley during the Woodland period practiced intensive horticulture as just one part of their hunting and gathering subsistence strategy.

Cleland (1976: 65) posits that one consequence of a diffuse adaptation would be the development of territorality to protect a group's resources. To some extent, such a supposition may hold in the Ozarks. However, given a high degree of mobility, such territorality might be difficult to maintain. Moreover, other needs, such as social and biological, might tend to minimize the intergroup variability which would result from strict territorality (see Lee 1968). Thus, we might expect exchange of individuals, materials, and ideas between groups, resulting in a fairly wide spatial distribution of similar mortuary practices and artifact types and styles. Burial might be segregated by individual group, or perhaps be an activity carried out during periods of aggregation of several groups; but whichever, it would involve behaviors or practices learned supralocally.

If the population(s) in southwest Missouri had little contact with populations outside the region and if there were little environmental change, we would expect cultural change to have been gradual. Environmentally induced cultural change has been hypothesized for the area, but for a period during the mid-Holocene when there was a gradual shift from a forest edge to a prairie biotype, and back (McMillan 1976b: 228). Since about 3000 B.P., the environment is thought to have been forest edge, and fairly stable.

If these conditions of isolation and environmental stability did exist, we might expect slow and gradual

cultural change. This should be manifest in several domains of the mortuary assemblages. Burial form and mound structure, as well as types and styles of artifactual inclusions should change slowly, if at all. This continuity in artifact form might be evident within a single assemblage, with diagnostically early artifact forms occurring in tumuli of a later time period.

Fred Eggan (1963), in discussing the role of isolation in cultural change, emphasizes Berreman's (1960: 788) belief that "cultural change, like genetic evolution, comes about as a result of variation, selection, and transmission while drift or divergent change requires the additional condition of isolation." Eggan points out (1963: 349) that random genetic drift increases in importance as the size of the breeding population is reduced and that culture change may operate in a similar manner; being more rapid in small isolated groups. We would expect, then, that, if isolated, the cultural patterns of the populations in southwest Missouri were divergent from patterns in surrounding culture areas, and perhaps at a different rate of change.

The preceding model of the relationship between both cultural isolation and conservatism and the mortuary subsystem yields a number of expectations against which to examine the mortuary assemblages from southwest Missouri. The following analyses will use non-skeletal tumulus inclusions (primarily artifacts) and tumulus form and structure to determine the degree of fit between the expected effects of isolation and the archeological record. The results of such a comparison will allow a better understanding of the prehistoric cultural systems in southwest Missouri, as well as enable alterations of, or additions to, a model of isolation and conservatism.

Summarizing, the analyses will be directed toward answering the following research questions:

1. Are the tumuli in southwest Missouri the result of cultural developments within the region? If so, (a) similar structures may occur in the area during the Archaic period and (b) at least some of the artifact types in the tumuli should occur in pre-Woodland sites.

2. Is the population in southwest Missouri isolated from cultural developments in other regions? If so, (a) artifact types in the tumuli should be similar to those in other southwest Missouri sites and different from those in other regions and, (b) the form and structure of the tumuli should be confined to southwest Missouri.

3. If the population in southwest Missouri were not isolated, what degree of contact was maintained with outside populations? Was it a trade relationship? If so, (a) exotic goods should constitute a small percentage of the cultural inventory, (b) exotic goods should occur primarily in tumuli or other ceremonial contexts, (c) exotic goods may come from several different sources, (d) sources of exotic goods may change through time, and (e) trade items may be horizon markers from a horizon later in time than the southwest Missouri horizon within which they are found (i.e., cultural lag).

4. Is there a high degree of cultural homogeneity among populations which are isolated within a fairly homogenous environment? If so, (a) tumulus form and structure, (b) artifact types, and (c) artifact styles should be similar throughout the region.

5. Does cultural change progress slowly and steadily in a population which is isolated? If so, (a) cultural change in southwest Missouri should progress at a different rate than that in other less isolated areas and (b) tumulus and structure and artifact types and styles should change gradually, if at all.

CHAPTER 5

FACTOR ANALYSIS

The artifacts from tumuli in southwest Missouri are indicative of a wide geographic and temporal range. They are representative of technologies occurring over a long period of time (Archaic - Mississippian) in the Eastern Woodlands and the Plains regions. In order to test whether the occupation and concomitant burial practices in southwest Missouri are conservative and regionally circumscribed, it is first necessary to assess the internal spatial and temporal patterning of the wide range of artifact types found in the southwest Missouri burial tumuli. Once the cultural-historical patterning is ascertained, the problem of determining the nature of the relationship of the population(s) can be addressed.

The immediate problem, then, is to determine the cultural relationship of the tumuli within the region to one another. If the southwest Missouri populations are conservative, isolated, and stable, it would be expected that the burial complex would show little spatial variability and either no temporal variability or slow change through time. There should be both spatial and temporal continuity within the mortuary complex, and thus in the assemblages of artifacts interred as burial accoutrements within the tumuli.

In an attempt to define the culture history of the burial tumuli, a factor analysis was performed to discern the patterning of variability in artifact types found within them. The results are groups of artifact types which were associated within the sample. It is hoped that resultant groups will have cultural meaning, reflecting temporal, spatial, and/or cultural differences between tumuli.

A similar analysis was done by Vehik (1977) using many of the same tumuli. However, his approach and sample differed from the present analysis in that the present analysis uses: (a) a much larger, more variable sample, (b) no skeletal/burial data, (c) rank-order, rather than presence/absence, data, and (d) groupings of artifacts, rather than of tumuli. The results seem to be more interpretable and meaningful.

Factor analysis is used here as a device for discerning regularity in a sample of the artifacts found in the tumuli, by measuring the correlation between a number variables (Rummel 1970). Factor analysis will reduce the number of

independent observations necessary to describe the data (Benfer 1967). If there is cultural patterning in the distribution of artifacts, it should be apparent in the resultant groupings. If the artifact inventory changed through time, artifacts from each period should co-occur and group together. Further, if there are any spatially distinct cultural units, regional artifact types should group together. Finally, if there is a uniform pattern of trade relationships with groups outside of southwest Missouri, variable grouping should indicate the nature of the trade (i.e., whether exotics from different areas occur together in the same tumuli).

Additionally, an analysis of the resultant factor scores (i.e., a measure of which tumuli are accounting for the artifact groupings) will enable a determination of the relationship between various temporal and spatial patterns discerned from the factor loadings. For instance, a tumulus may score highly on two different factors, both of which represent a different temporal component. Such would be the case if there is cultural continuity through time, with the addition of new types to the artifact inventory, rather than total replacement of one type by another. Similarly, a tumulus may score highly on two factors which represent spatially different cultural assemblages, if there were any overlap or interaction between those manifestations. The same situation could occur if the trade relationship between the builders of a tumulus and populations outside the area were varied. For instance, there may be factors which identify complexes of exotic goods traded in from specific regions. That any one tumulus scores highly on several of these factors would indicate that the builders interacted with peoples from more than one region. Also, if there were a change in the direction of the trade relationship through the history of one indigenous group, artifacts from distinct regions collected at different times could have been curated, and deposited with the dead, at one time, thereby creating an assemblage which is seemingly mixed. Thus, analysis of cultural, spatial and temporal continuity or variability must proceed by the examination of both groupings of artifacts (factors) and the contribution which the artifact assemblage of each tumulus makes in the creation of the factors (factor scores).

The Sample

Fifty cases, or tumuli, were chosen as a sample for the present analysis. It is not known how representative these tumuli are of the range of mortuary practice in southwest Missouri. However, the composition of the sample can be attributed to the history of archeological research in the area. All of the tumuli in the sample were excavated prior to 1970. All work on them was performed as a part of the

archeological survey and testing carried out prior to the filling of various reservoirs in the area — Pomme de Terre, Stockton and Kaysinger Bluff (now known as Harry S. Truman). Sites excavated during this research were either found during these surveys or had been previously recorded by local amateurs. Thus, the sample is not continuous across space, as excavation was confined to the reservoir boundaries. Also, it is not known what portions or in what manner survey was carried out. Additionally, there may be some problems with comparability of data from different tumuli. Several different excavators carried out excavations in different areas, at various times. There were clearly several different techniques of excavation and recording location of finds and in recovery techniques (e.g., screening, troweling) employed by different investigators. These problems in comparability are probably minimal, however, because in all cases the tumuli were totally excavated and the main purpose of the work was to recover the burial accoutrements. There is also the problem of possible complete destruction of formerly existing tumuli by looters. All presently known tumuli are on hilltops or bluff tops. Floodplain mounds may at one time have existed, but have since been destroyed by clearing and plowing.

The criteria used for including any tumulus in the sample were that: (1) it was located in southwest Missouri, (2) it had been excavated, (3) either the materials were curated at University of Missouri and were accessible for analysis, or the materials had been described and illustrated sufficiently for classification of tumulus and artifacts into the types used in the present analysis, (4) the tumulus was a small dome-shaped mound of either rock or rock and earth fill, and (5) it contained artifacts of at least two types used as variables in the present study.

The sample includes all tumuli defined by Wood (1961, 1967), Bray (1963b), Bradham (1963), and McMillan (1965a, 1968b) as belonging to the Fristoe Burial Complex. It also includes several non-Fristoe Burial Complex tumuli excavated during investigations in the Stockton (Wood, unpublished manuscript) and Pomme de Terre reservoirs (see Table 1 and Fig. 4). This includes several tumuli which are presently unassigned to any complex. Although these other tumuli possess some traits different from those of tumuli typical of the Fristoe Burial Complex, there are several reasons for combining all tumuli which meet the five criteria listed above. First, all tumuli appear to be similar in structure, size, and position on the landscape. Burial modes are also similar, with most tumuli containing primary, secondary, bundle, and broadcast[2] bodies; some burned and some unburned

[2]Broadcast burials consist of fragmented (burned and unburned) human bone, scattered through the tumulus.

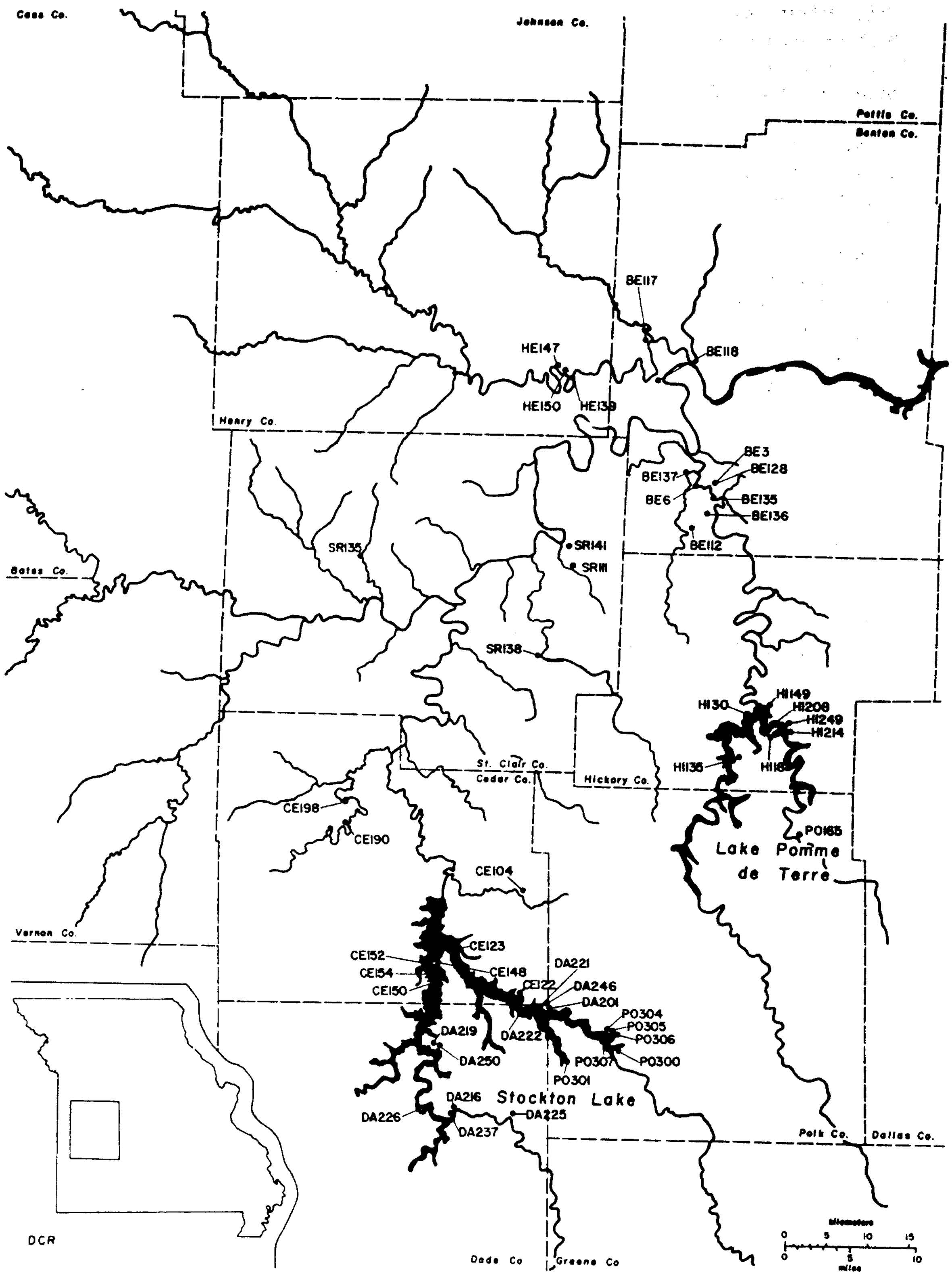

Figure 4. Tumuli in the sample.

TABLE 1

Burial Tumuli Used in the Sample and
Their Previous Cultural Assignments

I. PRECERAMIC

<u>Afton Burial Complex</u>

HI-135	Holbert Bridge Mound (Wood, 1961)	
PO-305	Colline "Mound" (Wood, MS)	

II. WOODLAND

<u>Fristoe Burial Complex</u>

BE-6	Mound 1	Fairfield Mound Group (Wood, 1961, 1967)
BE-6	Mound 2 (cairn)	
BE-6	Mound 3 (cairn)	
BE-6	Mound 4	
BE-3	Wray-Martin Mound 1 (Wood, 1967)	
BE-128	Wray-Martin Mound 2 (Wood, 1967)	
BE-112	Gist Ridge Cairn (Wood, 1967)	
BE-117	Karr's Camp Mound (Wood, 1967)	
BE-118	Devil's Bluff Mound (Wood, 1967)	
BE-135	Melanin Mound 1 (Wood, 1967)	
BE-136	Melanin Mound 2 (Wood, 1967)	
CE-104	Simmons Mound (Bradham, 1963)	
CE-122	Clemons Mound (McMillan, 1968b)	
CE-123	Broyles Mound (Chapman and Pangborn, 1962)	
CE-190	Amity Mound (McMillan, 1968b)	
CE-198	Alberti Mound (McMillan, 1968b)	
DA-201	Morgan Mound (Wood, 1961, 1967)	
HE-139	Mandrake Mound (Wood, 1967)	
HI-30a	Indian Hill Mound (Bray, 1963b)	
HI-30c	Murelle Mound (Wood, 1961)	
HI-149	Cave Knob Mound (Wood, 1961	
HI-209	Lindley Arm Mound (Wood, 1967)	

TABLE 1: Continued

Burial Tumuli Used in the Sample and Their Previous Cultural Assignments

	SR-111	Monteverdi Mound (Wood, 1967)
	SR-135	Woody Cairn (Chapman, 1965)
	SR-138	Magistrate Bluff Mound (Wood, 1967)
	SR-141	Briley Creek Mound (Wood, 1967)
	HE-148	Mt. Ilo Cairn (Falk and Lippincott, 1974)
	HE-150	Eckhardt Cairn (Falk and Lippincott, 1974)
	Unassigned	
	CE-148	Umber Point Mound (Wood, MS)
	CE-150	Sorter Mound (Wood, MS)
	CE-152	Bowling Stone Mound (Wood, MS)
	CE-154	Sycamore Bridge Mound (Wood, MS)
	DA-222	Tunnel Bluff Mound (Wood, MS)
	DA-225	Bunker Hill Mound (Wood, MS)
	DA-226	Divine Mound (Wood, MS)
	DA-246	Paradise Tree Mound (Wood, MS)
	PO-306	Slick Rock Mound (Wood, MS)
III.	MISSISSIPPIAN	
	Unassigned	
	PO-300	Madrigal Mound (Wood, MS)
	PO-301	Petit Cote Cairn (Wood, MS)
	PO-307	King's Curtain Mound (Wood, MS)
	HI-18	Lytle Cairn (Wood, 1961)
	HI-30	Mount India Cairn (Wood, 1961, 1976c)
	HI-209	Button Cairn (Bray, 1963a)
	PO-304	Cordwood Cairn (Wood, MS)
	DA-250	Eureka Mound (Wood and Pangborn 1968a; Pangborn, 1966)
	DA-216	Sand Bluff Cairn (Wood, MS)
	DA-237	Turnback Cairn (Wood, MS)

TABLE 1: Continued

Burial Tumuli Used in the Sample and Their Previous Cultural Assignments

IV. UNASSIGNED PREHISTORIC

DA-219 Matthews Mound (Wood, MS)

BE-137 Barren Cairn (Wood, MS)

HE-147 Gobblers Knob Cairn (Falk, 1969)

PO-165 Star Ridge Cairn (Wood, 1961)

V. HISTORIC

<u>Unassigned</u>

DA-221 Comstock Mound (Wood and Pnagborn, 1968a; Pangborn, 1965)

burials. These similarities would indicate that there is some degree of cultural continuity in mortuary custom within the region and through time. Variables which would be expected to vary most through time and space are the artifacts. Including, in one sample, tumuli which have some different artifact types (although most contain artifacts of similar types) may lead to stronger spatial and temporal differentiation, if it exists. Also, by using a multivariate statistical technique, the utility of previous classification of tumuli into complexes (see Table 1) can be evaluated.

The Variables

The traits (55 variables) consisted of fifty-two artifact types, two variables representing mound structure and form, and one variable accounting for the presence of corn. Such a large number of variables (five more than the number of cases) violates the necessity in common factor analysis, that the number of cases should exceed the number of variables. However, since the present analysis uses principal components to describe the data (cf., Rummel 1970: 219-220; Benfer 1979), all fifty-five variables were retained. This enabled inclusion of as much artifactual variability as might be necessary to explain temporal, spatial, and cultural relationships amongst the tumuli. The fifty-five variables do not represent all tumulus inclusions, but only these fifty-five were both felt to be potentially spatially or temporally diagnostic, and present in at least two cases. Some of these remaining traits will be helpful in interpretation but will not be used in the factor analysis (see Table 2 for frequencies of all inclusions).

Description of Artifact and Trait Types

A brief description of the fifty-five classes of artifacts and structure attributes used as variables is found in Appendix A. The word "classes" rather than "types" is used here, because not all of these categories conform to type names currently in use. The present classes were formed to describe as much variability within the tumuli as might be needed to explain temporal, spatial, and cultural factors. Yet, there is a point where some of the variability may be too trivial to explain anything more than individual, idiosyncratic behavior. Thus, there are some classes which seem to be very broad functional classes, not bounded by specific formal attributes.

At the same time, there are two major classes of artifact types (arrow points and dart points) which are broken down into several smaller, formal classes. Stylistic complexity of these two classes of artifacts is inherent. Moreover, they have always played a large role as indicators of

spatial and temporal variability. Since the goal in the present study is to place the tumuli in a spatial and temporal framework and then to evaluate the relationship of these tumuli to other cultural manifestations, it is necessary to use these smaller, formal classes as horizon markers. In so doing, it seemed best to classify on the basis of previously defined types when the artifacts could clearly be assigned to such categories. This should permit a simple, general comparison between artifacts from the southwest Missouri tumuli and artifacts from surrounding areas. Of course, such comparisons must be used with caution. Regional differences in technology might be obscured by categorizing artifacts into a classification scheme which was formed for artifact assemblages in other regions.

In some instances, assignment of certain artifacts to previously defined classes was difficult. Some points in the sample possessed attributes typical of two previously defined types, but fitted neither one. When this formal gradation of one type into another occurred, it was necessary to use statistical attribute analysis to form groups. To this end, all projectile points were measured and coded in a manner similar to that used by Ahler (1970). Using these data, in cases where point assignment and class formation was tenuous, classifications were performed by means of numerical taxonomy. Details of these analyses are found in Appendix A.

The descriptions (Appendix A) include the general form and function of the artifact class. For projectile forms, this includes discussion of the morphological form of the blade, notches, shoulders, stems, and bases. For other classes of artifacts, general descriptions of class attributes are included, as well as an indication of the range of the variability of the artifacts within the class.

Appendix A also includes a set of summary statistics of the metric and non-metric attributes of the projectile points. As not all of the points were available for measurement, there is some discrepancy between the number of points used for the factor analysis and the number in the sample used to obtain the summary statistics. Appendix A also includes a discussion and definition of the attributes measured on each group of points.

Appendix A also includes the proposed temporal placement of each type, its geographic range, and from this, what cultural affiliation might be implied. To aid in such interpretations, two lines of evidence were used. First, several volumes of artifact typologies (Perino 1968, 1971; Bell 1958, 1960; Purrington 1971; Marshall 1958) which include a general discussion of temporal and spatial distribution of point

types were drawn on for a general overview. Second, a number of site reports from archeological investigations in areas surrounding southwest Missouri were consulted. A comparison of the traits of the southwest Missouri tumuli with assemblages in these other areas is made in Table 21, Appendix B. An artifact or attribute was considered present when descriptions, figures, or plates, in these site reports compared favorably with the southwest Missouri mortuary assemblages.

The fifty-five artifact and structural classes, described in Appendix A, to be used in the factor analysis are:

I. Chipped Stone Artifacts

A. Arrow Points

Scallorn
Haskell
Keota
Late Woodland
Fresno
White River Elliptical
Crisp Ovate
Huffaker
Harrell
Washita
Reed

B. Dart Points

Rice Side-Notched
Cooper-like corner-notched
Variant of Rice Side-Notched
Guffy-like
McConkey
Delaware
Marshall
Table Rock Stemmed
Cupp
Etley-like
Afton
Standlee (Langtry)
Gary
Snyders (Weber, Norton, Snyders Affinis)

C. Drills

F-type drills
Other drills

II. Ground Stone

Celts
Pebble Mano
Shaped Mano
Hematite

III. Pipes

Ground Stone
Pottery

IV. Ceramic Vessels

Shell-tempered smooth
Shell-tempered cordmarked
Calcite-tempered cordmarked
Grog-tempered smooth
Limestone-tempered smooth
Limestone-tempered cordmarked
Sand-tempered smooth

V. Native Copper

VI. Corn

VII. Bone Artifacts

Cut wolf-maxilla
Beads
Turtle
Awl/Pin
Antler cylinders
Other bone tools

VIII. Shell Artifacts

Anculosa/periwinkle beads
Mollusk beads
Marine Shell beads
Conch Pendant

IX. White Trade Goods

X. Tumulus Structure

Mound/cairn
Internal structure

The data originally consisted of raw counts (Table 2). It was observed from univariate frequency distributions that the variables required some transformation toward normalcy. Previous factor analyses, attempted with similar data, used

TABLE 2

Frequencies of All Artifacts by Tumulus

	Scallorn	Rice Side Notch	Cooper-like	Snyders Group	Guffy-like	Standlee	Gary	McConkey	Cupp	Table Rock	Marshall	Delaware	Fresno	White R. Elliptical	Crisp Ovate	F-Drill	Other Drill	Haskell	Huffaker	Washita	Harrell	Reed	Late Woodland	Keota	Stone Pipe	Pottery Pipe	Celt	Pebble Mano	Shaped Mano	Copper	Shell Smooth	Shell Cordmarked	Calcite Cordmarked	Grog Smooth	Limestone Smooth	Limestone Cordmarked	Sand Smooth	Corn	Cut Wolf Maxilla
BE6-1	11	15	6	-	-	2	1	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	1	1	-	-	-	-	-
BE6-2	108	51	24	1	-	-	-	-	-	1	-	-	2	1	-	-	3	-	3	-	-	1	2	-	-	-	-	3	-	-	1	2	-	1	-	-	-	-	-
BE6-3	38	15	10	-	1	-	1	-	-	-	-	-	4	2	-	-	3	-	1	-	1	2	1	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
BE6-4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	3	-	-	-
BE112	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE117	13	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
BE3	4	19	4	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
BE128	8	4	1	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE118	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE135	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE136	-	3	2	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE104	33	1	-	-	-	-	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-
CE122	-	18	36	-	2	-	-	-	-	1	-	-	1*	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
CE123	4	4	-	-	-	1	-	-	-	-	-	-	3	-	1	-	-	-	10	5	3	1	-	-	-	1	1	2	-	-	-	-	-	-	1	-	-	-	-
CE190	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE198	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA201	3	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE139	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
HI30	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-	-	-
HI30A	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
HI30C	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI149	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-

TABLE 2: Continued

Frequencies of All Artifacts by Tumulus

	Scallorn	Rice Side Notch	Cooper-like	Snyders Group	Guffy-like	Standlee	Gary	McConkey	Cupp	Table Rock	Marshall	Delaware	Fresno	White R. Elliptical	Crisp Ovate	F-Drill	Other Dril	Haskell	Huffaker	Washita	Harrell	Reed	Late Woodland	Keota	Stone Pipe	Pottery Pipe	Celt	Pebble Mano	Shaped Mano	Copper	Shell Smooth	Shell Cordmarked	Calcite Cordmarked	Grog Smooth	Limestone Smooth	Limestone Cordmarked	Sand Smooth	Corn	Out Wolf Maxilla
HI209	5	16	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
SR111	-	2	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR135	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR141	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE148	16	9	4	-	-	-	-	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	4	-	-	-	3	+	-	-	-	1	-	-	-	+	-
CE150	13	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	2	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	+	-
CE152	5	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	1	-	1	2	-	-	+	-
CE154	27	-	-	-	-	-	2	2	-	-	-	-	1	-	9	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
DA222	13	-	-	-	-	-	1	-	1	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	3	-	-	1	3	+	-	-	-	-	1	-	-	+	-
DA225	14	-	-	-	-	1	-	-	-	-	-	-	-	1	3	1	-	-	2	-	-	1	-	1	2	1	1	-	1	-	-	1	-	-	-	1	-	+	-
DA226	12	1	-	-	-	-	-	-	-	-	-	1	1	2	1	-	-	-	-	-	-	1	-	-	2	1	1	-	-	-	-	-	-	-	1	-	-	+	-
DA246	1	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	+	-
PO306	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	3	-	1	-	-	-	+	-	-	-	-	-	1	-	+	-
PO300	2	1	1	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	+	1	1	-	-	1	1	-	-	-
PO301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
PO307	7	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	10	-	-	1	-	-	-	1	-	-	-	+	1	-	-	-	-	-	-	+	-
HI18	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
HI208	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	7	2	3	-	-	-	-	-	-	-	-	-	4	-	-	-	-	1	-	+	-
PO304	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA250	1	1	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
DA216	5	5	-	-	1	1	-	-	-	-	1	-	-	-	-	-	-	-	11	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	+	-
DA237	9	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

TABLE 2: Continued

Frequencies of All Artifacts by Tumulus

	Scallorn	Rice Side Notch	Cooper-like	Snyders Group	Guffy-like	Standlee	Gary	McConkey	Cupp	Table Rock	Marshall	Delaware	Fresno	White R. Elliptical	Crisp Ovate	F-Drill	Other Drill	Haskell	Huffaker	Washita	Harrell	Reed	Late Woodland	Keota	Stone Pipe	Pottery Pipe	Celt	Pebble Mano	Shaped Mano	Copper	Shell Smooth	Shell Cordmarked	Calcite Cordmarked	Grof Smooth	Limestone Smooth	Limestone Cordmarked	Sand Smooth	Corn	Cut Wolf Mandilla
DA219	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	3	-	1	1	-	-	1	-	-	+	-
DA221	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
SR138	22	7	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE150	7	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE147	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE148	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Intrusive
+Present
-Absent

Single Occurrences:

CE152 Conch pendant
CE150 2 Bone nails
CE150 Metapodial wrench
PO307 Fish hook
PO304 2 Earspools
CE122 Atlatl weight
BE6-2 Mammiform object (cupstone?)
BE6-2 2 Whetstones
DA222 Metate
DA250 Spiro water bottle

TABLE 2

Frequencies of All Artifacts by Tumulus

	Anculosa Beads	Periwinkle Beads	Marginella Beads	Oliva Beads	Mollusk Disk Bead	Conch Disk Beads	Other Conch Beads	Conch Gorget	Bone Awl/Pin	Bone Beads	Antler Cylinder	Metapodial Pin	Ulna Flaker	Butted Spatula	Embellished Spatula	Worked Turtle	Hematite	White Trade Goods	RSN Variant	Etley-Like	Afton	Other Archaic Dart Points	Unclassified darts	Unclassified Arrows	Leaf Shaped Knives	Triangular Knives	Oval Knives	Gouge	Scrapers	Choppers	Flake Scrapers	Flake Knives	Flakes w/Use Retouch	Waste Flakes	Cores	Hammerstones	Pebble Hammer	Galena
BE 6-1	-	-	1	-	8	25	7	-	2	-	-	-	-	-	-	-	4	-	4	-	-	-	10	1	-	1	-	-	2	5	3	2	41	153	-	-	-	-
BE6-2	-	-	3	-	-	23	2	1	-	-	1	1	-	-	-	-	2	17	2	-	-	3	24	-	7	17	-	-	1	5	18	21	131	488	-	-	-	-
BE6-3	-	-	-	-	16	-	-	-	-	-	-	-	-	-	-	-	6	8	1	-	-	1	4	5	3	2	-	-	-	9	17	8	115	897	-	-	-	-
BE6-4	8	-	-	1	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	4	5	28	47	-	-	-	-
BE112	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2	-	-	-	-	-	1	1	-	-	-	-	-	-	1	-	5	23	-	-	-	-
BE117	12	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	1	-	1	-	2	-	-	-	15	55	-	-	-	-
BE3	5	-	-	-	-	-	-	-	6	-	-	1	-	-	-	-	-	-	-	-	1	1	6	1	3	3	2	1	1	-	3	2	17	70	-	-	-	-
BE128	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	1	-	-	-	-	-	-	-	4	-	6	23	-	-	-	-
BE118	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	1	-	-	-	-	-	-	-	2	2	26	49	-	-	-	-
BE135	9	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	5	3	8	115	-	-	-	-
BE136	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	4	-	1	1	-	-	1	-	1	-	10	38	-	-	-	-
CE104	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-
CE122	-	-	1	3	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	1	-	-	2	1	-	-	-	-	-	2	-	-
CE123	12	-	-	-	-	21	2	-	2	4	-	-	-	-	-	-	10	-	-	-	-	-	1	-	-	1	-	-	-	4	-	-	-	-	-	-	-	-
CE190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	4	1	5	-	38	-	-	-	-
CE198	-	-	-	-	-	-	41	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3	-	1	-	-	7	3	-	-	25	-	-	-	-
DA201	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	2	1	12	5	-	-	-	-
HE139	4	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	3	15	-	-	-	-
HI30	8	-	-	-	-	27	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	45	155	-	-	-	-
HI30A	2	-	-	-	2	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3	-	1	-	-	-	-	+	-	-	-	-
HI30C	2	-	-	-	2	1	-	-	1	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-
HI149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3	-	-	-	-	-	3	3	11	63	-	-	-	-

TABLE 2: Continued

Frequencies of All Artifacts by Tumulus

	Anculosa Beads	Periwinkle Beads	Marginella Beads	Oliva Beads	Mollusk Disk Bead	Conch Disk Beads	Other Conch Beads	Conch Gorget	Bone Awl/Pin	Bone Beads	Antler Cylinder	Metapodial Pin	Ulna Flaker	Butted Spatula	Embellished Spatula	Worked Turtle	Hematite	White Trade Goods	RSN Variant	Etley-like	Afton	Other Archaic Dart Points	Unclassified Darts	Unclassified Arrows	Leaf Shaped Knives	Triangular Knives	Oval Knives	Gouge	Scrapers	Choppers	Flake Scrapers	Flake Knives	Flakes w/Use Retouch	Waste Flakes	Cores	Hammerstones	Pebble Hammer	Galena
HI209	2	-	-	-	-	-	1	-	1	20	6	-	-	-	-	-	2	-	-	-	-	-	1	1	-	2	3	-	1	1	-	-	-	-	-	-	-	-
SR111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
SR135	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	3	-	-	-	-	-	-
SR141	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	3	1	3	28	-	-	-	-
CE148	15	-	15	-	1	1	3	-	3	2	-	1	-	1	-	+	2	-	-	-	-	-	6	-	-	-	-	-	1	-	8	2	20	144	2	-	-	-
CE150	45	26	52	-	93	6	-	-	-	2	-	-	-	9	-	+	-	-	-	-	-	-	1	-	-	-	-	-	-	2	2	-	20	47	-	-	1	-
CE152	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	4	-	4	2	-	-	-	-	1	-	22	90	-	-	-	-
CE154	-	-	-	-	-	1	2	1	1	-	-	-	-	1	-	+	-	-	-	-	-	2	16	9	-	-	-	-	1	-	9	1	117	303	1	-	-	-
DA222	10	23	-	-	-	9	-	1	2	5	-	1	6	3	2	+	1	-	-	1	-	1	1	-	4	-	-	-	-	-	1	1	12	42	-	-	1	-
DA225	292	-	-	-	-	2	2	-	-	2	-	1	1	1	-	+	-	-	-	2	-	-	1	3	4	-	-	-	1	1	1	-	19	98	-	-	-	-
DA226	1	-	-	-	-	3	1	1	-	1	1	3	2	1	-	+	4	-	-	-	-	1	2	-	-	-	-	-	-	-	2	3	8	10	-	-	2	-
DA246	39	-	-	1	12	10	2	-	3	4	-	-	-	3	1	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	17	59	-	-	-	-
PO306	57	-	17	-	15	-	5	-	-	-	-	1	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	5	4	17	75	-	-	-	-
PO300	251	15	-	-	-	7	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	6	13	-	-	-	-
PO301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	5	26	-	-	-	-
PO307	165	-	25	-	-	26	6	2	3	-	-	1	-	-	-	-	1	-	-	-	-	1	1	-	2	1	1	-	-	-	5	3	2	20	-	-	-	+
HI18	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-
HI208	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	18	-	-	-	-
PO304	-	-	107	-	-	7260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	4	2	35	11	-	-	-	-
DA250	-	-	-	-	-	-	-	-	4	-	1	-	3	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	3	1	24	94	-	-	1	-
DA216	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	4	4	-	-	-	-	3	-	-	-	25	130	1	-	-	+
DA237	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	1	12	62	-	-	-	-

TABLE 2: Continued

Frequencies of All Artifacts by Tumulus

	Anculosa Beads	Periwinkle Beads	Marginella Beads	Oliva Beads	Mollusk Disk Bead	Conch Disk Beads	Other Conch Beads	Conch Gorget	Bone Awl/Pin	Bone Beads	Antler Cylinder	Metapodial Pin	Ulna Flaker	Butted Spatula	Embellished Spatula	Worked Turtle	Hematite	White Trade Goods	RSN Variant	Etley-like	Afton	Other Archaic Dart Points	Unclassified Darts	Unclassified Arrows	Leaf Shaped Knives	Triangular Knives	Oval Knives	Gouge	Scrapers	Choppers	Flake Scrapers	Flake Knives	Flakes w/Use Retouch	Waste Flakes	Cores	Hammerstones	Pebble Hammer	Galena
DA219	43	-	-	-	8	15	1	-	1	-	-	5	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	12	51	-	-	-	-
DA221	-	-	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-	18	-	-	-	-	6	-	3	2	1	-	-	3	2	2	59	108	-	-	-	-
SR138	-	-	-	-	4	-	23	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	11	-	2	1	-	-	-	-	5	10	14	97	-	-	-	-
HE150	39	-	6	-	-	3	7	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	-	-	-	-	-	-	-	1	-	-	2	-	50	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	1	1	-	-	-	1	7	3	80	61	-	-	-	-
BE137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	7	9	-	-	-	-
HE147	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	21	2	-	-	-
PO165	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3	17	-	-	-	-
HE148	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-

a log (log+1) + 1 transformation to normalize the distribution. Results from those analyses showed that artifacts which, by their nature, may be over represented (i.e., do 100 beads represent one necklace or 100 artifacts?) were skewing the analyses. It was decided, instead, to use a rank order transformation (Anderberg 1973: 56). The distinctions which seemed important were "none," some," or "many," so the data were coded as follows:

0 = none present
1 = frequency is below the column mean of all non-zero counts
2 = frequency is above the column mean of all non-zero counts

Technique

An R-mode factor analysis was used, since the objective of the study was to describe the patterning of the variability of artifact distributions between assemblages. Such an analysis provides a factor score for each tumulus on each factor, making it possible to determine which tumuli accounted for the artifact groupings. These results will be used to describe the cultural relationships between tumuli.

The factor analysis was a principal components analysis, with dimensions explaining both shared and unique variation of artifact classes. Common factor analysis which would have considered only shared variation was rejected since the sample was known to be heterogeneous, i.e., from Fristoe and non-Fristoe tumuli. All calculations were done using Program FACTOR (Veldman 1967: 222-225).

To determine the number of dimensions needed to explain the variation within the sample, all fifty-one roots were extracted, and a scree diagram plotted (Fig. 5). There were obvious breaks in the curve at six, eight, ten, and sixteen factors. A principal components analysis rotating ten factors revealed that more factors were needed to describe the variability of the sample. Also, sixteen factors were closer to an eigenvalue 1.0 criterion. Sixteen factors were extracted for the present analysis to describe the extremely heterogeneous sample.

Using the Varimax procedure, the first sixteen factors were rotated to an orthogonal simple structure. Factor loadings $\geq |.20|$ are presented in Table 3. Factors 1 to 16 respectively account for approximately 10%, 6%, 7%, 5%, 5%, 4%, 4%, 4%, 4%, 3%, 5%, 4%, 4%, 4%, 6%, and 3% of the total variance, totalling 78%.

To determine the extent of correlation between the sixteen factors, an oblique rotation of the principal

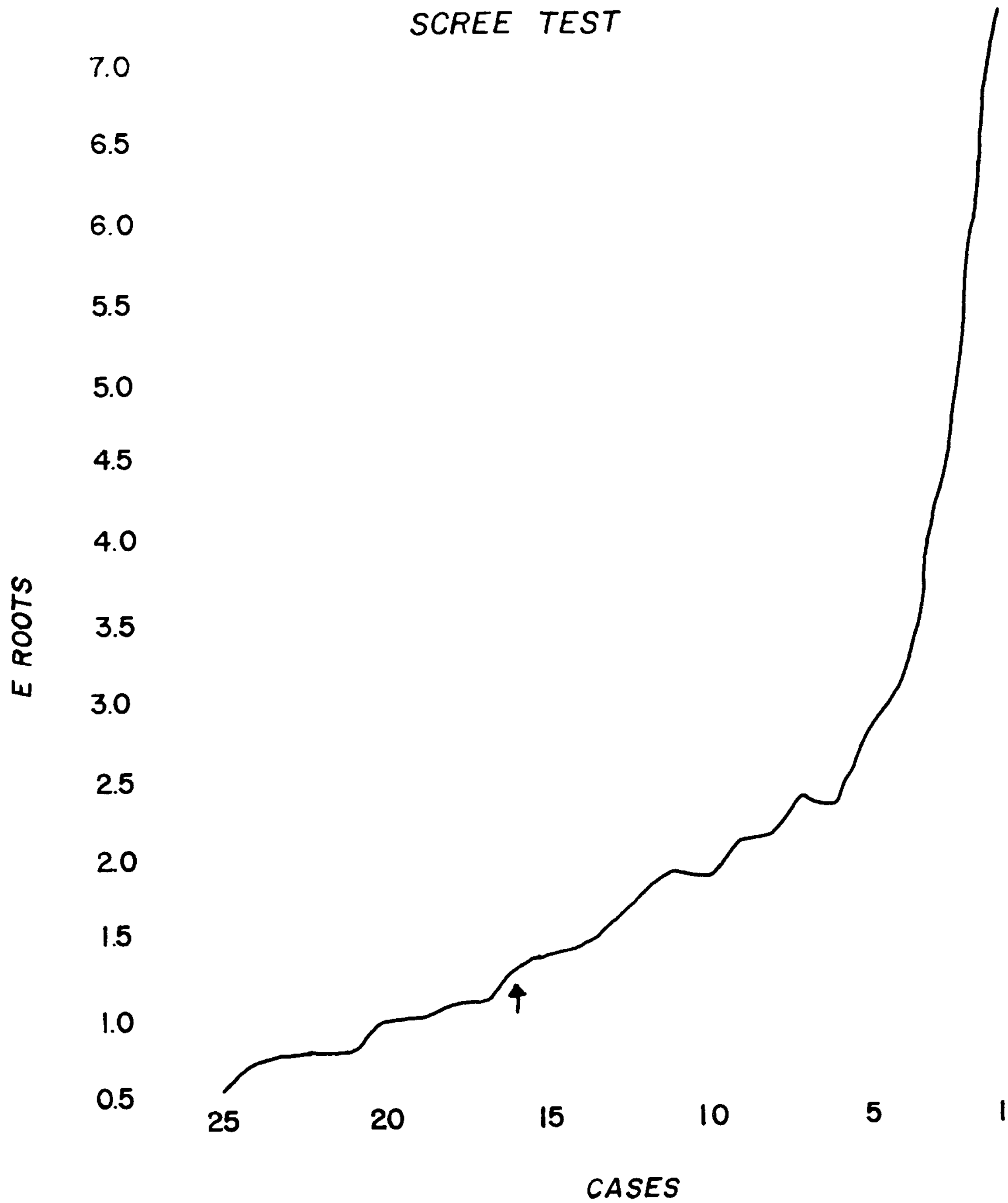

Figure 5. Scree test of principal components analysis.

components was performed. Using Program FAC4M (Dixon and Brown 1977) and a direct quartimin rotation, it is shown that the roots are, in fact, virtually orthogonal to each other; the highest correlation being between Factors 1 and 4 (+.202). The other correlations range between +.198 and -.124 (see Table 4), with most between -.100 and +.100.

Factor 1 is characterized by high loadings on stone pipes and Cupp points and intermediate loadings on corn, worked turtle shell, shaped manos, bone beads and other bone artifacts. Factor 2 had a high loading on Table Rock Stemmed points and moderate loadings on Cooper-like corner-notched, Guffy-like, and Rice Side-Notched points, as well as generalized drills. Washita and Harrell points loaded highly and Huffaker, moderately, on Factor 3. Factor 4 had high loadings on Gary and McConkey points. Factor 5 had high loadings on Keota points and limestone-tempered cordmarked pottery. Afton points loaded highly and cut wolf maxillae, intermediately, on Factor 6. Factor 7 had two intermediate loadings: marine shell beads of various forms and conch pendants. White trade goods and Delaware points loaded highly on Factor 8, with a moderate loading of Fresno points. Factor 9 had intermediate loadings on limestone-tempered smooth surface pottery and celts. Factor 10 had only one fairly high loading: Haskell points. Factor 11 had one high loading on mollusk shell beads. Factor 12 was characterized by intermediate loadings on shell-tempered pottery, both cordmarked and smooth surfaces. Factor 13 had an intermediate loading on antler cylinders. Factor 14 had a moderate loading on F-type drills. Factor 15 had a high loading on the Rice Side-Notched variants and intermediate loadings on Langtry points and calcite-tempered pottery. Factor 16 had a high loading on sand-tempered pottery.

Communalities (Table 3) range from .57 to .92. Some of these values tend to be low for two reasons. First, the rank-order scale of measurement, which attenuated the data since only three values were possible, weakened the correlations. Second, given that the sample was heterogeneous, the low communalities reflect non-shared variation. Using a common factor analysis model, rather than the principal components model, would have lowered the communalities. Moreover, indications of idiosyncratic inclusions would have been lost. This non-shared variation may be useful in assessing the cultural relationships between tumuli and with units outside the region.

Factor scores are used to determine which tumuli contained combinations of variables which were responsible for high factor loadings in the principal components analysis. These are presented (Table 5) with scores $\geq |1.00|$, underlined.

TABLE 3

Factor Loadings from Principal Components Analysis

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Communality
	Orthogonally Rotated Factors																
Scallorn	.32			-.31							.37			-.47	.35		85
Rice Side-Notched		.61				.33									.35		74
Cooper-like C-N		.69													.35		73
Snyders group						.51				.40						-.33	63
Guffy		.64										.42					78
Langtry (Standlee)															.77		78
Gary				-.86													86
McConkey				-.89													87
Cupp-like	.84																85
Table Rock Stemmed		.82															77
Marshall					-.34		.38							.31		-.30	70
Delaware-like								.86									82
Fresno			.52					.66									92
White River Elliptical	.30												-.55		.41		77
Crisp Ovate	.56			-.34					.38					-.37			81
F-drill														-.74			71
Other drill		.60				.37											79
Haskell										.69							57
Huffaker			.68													-.30	76
Washita			.88														89
Harrell			.88														87
Reed			.42			.34					.56						85
Late Woodland										.47	.41		-.33	-.42			84
Keota					-.84												75
Stone pipe	.87																86

TABLE 3: Continued

Factor Loadings from Principal Components Analysis

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Communality
	Orthogonally Rotated Factors																
Pottery pipe					-.43		-.45					.40					76
Celt									.63				-.37				79
Pebble mano			.42											-.35	.31		70
Shaped mano	.65												.35				70
Copper	.45						-.38			.37					.34		82
Shell pottery - smooth			.37									-.67					76
Shell pottery- cordmarked									.38			-.66					80
Calcite pottery - cordmarked															.79		88
Grog pottery - smooth		.56							.48						.36		83
Limestone pottery - smooth									.79								78
Limestone pottery - cordmarked					-.85												86
Sand pottery - smooth																-.78	73
Corn	.62				-.39									.30			86
Wolf maxillae						.65											57
Anculosa/Periwinkle beads	.34				-.42		-.46				.32						78
Mollusk beads											.87						88
Marine shell beads							-.71										77
Bone beads	.63											.36	-.34				77
Turtle shell	.73																77
Bone awl/pin	.50						-.35										68
Other bone artifacts	.60								.49		.37						86
Hematite			.30												.45	.35	71
Mound/Cairn			.48				.35										64
Structure		.45															70
Conch pendant				-.32			-.62										83

TABLE 3: Continued

Factor Loadings from Principal Components Analysis

	Orthogonally Rotated Factors																
Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Communality
Antler													-.77				73
Trade goods								.85									82
Rice Side-Notch Variant															.83		83
Etley-like	.58				-.41									-.48			80
Afton						.84											75
Percent of Variance	10.1	6.0	6.7	4.5	5.4	4.2	4.2	4.2	4.2	2.9	4.5	4.0	4.1	3.9	6.2	2.9	= 73.84

TABLE 4

Correlation Between Factors; Direct Quartimin Rotation

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Factor 1	1.00							
Factor 2	-0.00	1.00						
Factor 3	-0.00	0.06	1.00					
Factor 4	0.20	0.04	-0.05	1.00				
Factor 5	-0.02	-0.03	0.12	-0.06	1.00			
Factor 6	0.04	-0.01	0.12	0.00	-0.04	1.00		
Factor 7	0.03	0.02	0.11	0.01	0.01	0.06	1.00	
Factor 8	-0.10	-0.12	0.05	-0.10	0.09	-0.02	0.04	1.00
Factor 9	0.02	0.09	0.09	-0.00	0.10	0.04	0.03	-0.01
Factor 10	0.19	-0.05	-0.08	0.00	-0.03	0.03	-0.00	-0.03
Factor 11	0.08	0.08	0.07	0.01	0.07	0.09	0.10	0.03
Factor 12	-0.10	0.05	0.00	-0.10	0.00	0.04	0.00	-0.03
Factor 13	0.18	-0.02	0.04	0.08	0.01	0.03	0.06	-0.00
Factor 14	0.10	-0.01	0.06	-0.01	-0.01	0.08	0.00	0.02
Factor 15	-0.02	0.01	-0.10	0.04	-0.08	-0.00	-0.07	0.02
Factor 16	-0.08	-0.11	-0.04	-0.05	0.02	-0.03	-0.00	0.00

	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15	Factor 16
Factor 9	1.00							
Factor 10	-0.02	1.00						
Factor 11	0.00	0.03	1.00					
Factor 12	0.05	-0.00	0.06	1.00				
Factor 13	0.01	0.08	0.08	-0.06	1.00			
Factor 14	-0.02	0.08	0.05	0.00	0.08	1.00		
Factor 15	-0.03	0.02	-0.06	-0.06	-0.07	0.03	1.00	
Factor 16	0.01	-0.03	-0.00	-0.00	-0.00	-0.01	0.04	1.00

TABLE 5

Factor Scores of Tumuli on Sixteen Factors

Site	FACTOR 1	2	3	4	5	6	7	8
BE6-1	-0.24	0.18	-0.57	-0.31	0.35	-0.39	-0.62	-0.65
BE6-2	-0.99	2.52	0.17	0.62	0.38	0.46	-1.57	1.26
BE6-3	-0.24	1.16	0.94	-2.69	0.07	-0.22	1.80	1.54
BE6-4	-0.71	0.05	-0.33	0.64	0.50	-0.31	-0.20	-0.49
BE112	-0.21	-0.83	-0.15	0.23	0.44	-0.57	0.74	-0.18
BE117	-0.48	-0.09	-0.67	0.48	0.23	1.34	-0.35	-0.62
BE3	0.10	0.36	0.16	0.16	0.12	5.39	0.25	-0.26
BE128	-0.70	-0.02	-0.54	0.81	-0.24	0.08	-0.03	0.84
BE118	-0.59	-0.42	-0.28	0.35	0.61	-0.38	-0.03	-0.36
BE135	-0.40	-0.42	-0.36	0.52	0.10	-0.19	0.30	-0.18
BE136	-0.22	1.70	0.24	0.21	0.30	-0.18	0.37	-0.07
CE104	-0.34	0.05	0.24	-1.82	0.71	-0.23	0.28	-0.58
CE122	-0.49	5.07	-0.23	0.18	-0.13	-1.03	0.06	-0.14
CE123	-0.51	-0.71	5.12	0.77	0.44	0.71	-1.11	0.14
CE190	-0.51	-0.05	-0.72	-0.00	0.11	0.01	0.74	-0.34
CE198	-0.45	-0.07	-0.41	-0.49	0.75	-0.95	-1.97	-0.09
DA201	-0.49	-0.53	-0.50	-0.80	0.54	-0.06	-0.79	-0.34
HE139	-0.43	-0.73	-0.65	0.54	0.29	-0.22	-0.15	-0.00
HI30	-0.43	-0.16	1.26	0.30	0.55	-0.79	-0.65	-0.02
HI30a	-0.84	-0.54	-0.56	0.60	0.09	0.69	-0.73	0.07
HI30c	-0.54	-0.29	-0.42	0.26	0.50	-0.38	0.40	-0.24
HI149	-0.56	-0.61	-0.67	0.49	0.50	1.02	0.39	-0.36
HI209	0.51	1.00	-0.19	0.90	0.46	-0.11	0.40	-0.88
SR111	-0.21	-0.24	-0.10	-0.90	0.08	2.76	0.65	0.02
SR135	-0.51	0.06	-0.36	0.05	0.15	-0.06	0.99	-0.23
SR141	-0.36	0.14	-0.47	0.20	0.16	0.41	0.58	-0.28
CE148	3.59	1.50	-0.52	0.26	1.12	-0.00	-0.08	-0.49
CE150	0.17	-0.60	0.76	0.14	0.30	-0.14	-0.30	0.19
CE152	0.21	-0.21	-0.92	-0.19	0.19	-0.62	0.45	-0.13
CE154	0.09	-0.42	-0.19	-5.27	0.21	-0.41	-0.16	-0.11
DA222	4.18	-0.72	-0.17	-0.70	1.23	0.19	-0.49	-0.39
DA225	2.32	-0.22	-0.05	0.74	-3.78	-0.28	0.27	0.42
DA226	1.67	-0.93	0.22	-0.05	0.55	-0.18	-0.24	1.66
DA246	-0.01	0.60	0.04	0.76	-0.64	-0.65	-1.03	-0.54
PO306	-0.89	-0.16	-0.88	-0.88	-4.68	0.23	-1.47	0.09
PO300	0.52	-0.07	-0.11	0.56	-1.80	0.26	0.31	-0.80
PO301	-0.25	-0.63	-0.07	0.38	-0.11	-0.46	0.73	0.99
PO307	0.78	-0.45	0.09	-0.14	-0.16	-0.21	-3.89	-0.56
HI18	-0.39	-0.32	0.83	0.03	0.52	-0.12	0.36	0.03
HI208	0.20	0.02	3.28	0.01	-1.30	-0.86	0.85	-0.98
PO304	-0.83	-1.16	0.04	0.26	0.09	-0.69	0.21	-0.24
DA250	0.02	-0.00	-0.61	0.08	0.01	0.24	0.02	-0.63
DA216	0.57	-0.15	0.95	0.30	-0.03	-0.67	1.72	-0.56
DA237	-0.26	0.13	-0.21	-0.02	-1.26	-0.62	1.86	-0.25
DA219	0.92	-0.29	-0.42	0.87	0.40	0.37	0.15	-0.13
PO165	-0.06	-0.68	-0.30	0.41	0.36	-0.43	0.78	0.28
DA221	-0.05	-0.29	-0.59	0.62	-0.12	-0.20	0.03	5.97
SR138	-0.62	-0.06	-0.40	0.08	0.31	-0.93	-0.45	-0.71
HE150	-0.38	-0.67	-0.34	0.26	0.14	-0.09	-0.21	-0.39
HE148	-0.56	-0.70	-0.31	0.08	0.26	-0.43	0.76	-0.18

TABLE 5: Continued

Factor Scores of Tumuli on Sixteen Factors

Site	9	10	11	12	FACTOR 13	14	15	16
BE6-1	0.23	0.42	-0.10	0.19	1.07	0.49	5.81	0.25
Be6-2	0.76	1.25	-0.26	-3.41	-2.33	-1.90	0.81	-1.34
BE6-3	-1.43	-0.79	2.27	-0.88	-1.19	0.68	1.94	1.06
BE6-4	2.06	-0.27	0.03	-0.34	1.01	0.41	0.19	0.39
BE112	-0.52	-0.13	-0.44	0.25	-0.81	-0.08	0.10	0.37
BE117	-0.61	-1.64	0.32	-0.02	0.02	-0.48	0.01	0.55
BE3	-0.38	-0.36	0.54	-0.09	-0.05	0.46	-0.33	0.28
BE128	-0.12	-0.83	-0.28	0.55	0.46	-0.41	0.98	0.30
BE118	-0.36	-0.46	-0.20	0.36	0.16	-0.40	0.10	0.72
BE135	-0.09	-0.60	-0.33	0.25	-0.08	0.02	0.67	-0.15
BE136	-0.71	0.37	-0.65	1.32	0.45	-0.12	-0.55	-0.33
CE104	-0.75	-0.14	-0.50	0.22	0.46	-1.87	-0.16	-1.98
CE122	0.90	-0.48	-0.46	1.13	1.17	0.41	-0.95	0.30
CE123	1.63	0.14	-0.29	2.15	0.25	-1.13	1.04	0.45
CE190	0.60	-0.42	-0.54	0.29	-0.20	0.00	-0.02	0.43
CE198	-0.70	-0.50	-1.12	-0.53	0.32	0.05	-1.01	-0.27
DA201	-0.12	-0.28	-0.54	-0.00	0.26	0.25	-0.25	-0.04
HE139	-0.14	-0.56	0.08	0.13	0.65	-0.28	-0.12	-1.35
HI30	-0.96	-1.07	0.35	-2.04	0.26	-0.61	-0.98	1.43
HI30a	-0.04	0.49	0.89	0.50	0.47	-0.53	-0.21	-2.50
HI30c	-0.35	-0.64	-0.30	0.25	0.19	-0.32	0.14	0.65
HI149	-0.24	-1.32	-0.05	0.28	0.18	-0.22	0.00	-1.54
HI209	-0.34	-0.55	-0.52	1.45	-3.09	0.11	-0.51	1.50
SR111	-0.03	1.16	-0.85	0.51	0.69	0.73	-0.25	0.49
SR135	-0.28	-0.32	-0.36	-0.03	-0.11	0.03	-0.07	0.37
SR141	-0.19	0.06	-0.42	0.49	0.11	0.44	-0.15	0.61
CE148	-0.76	-0.14	0.67	-0.06	1.67	0.51	0.14	0.90
CE150	1.42	-0.56	4.52	0.32	0.31	-0.32	-1.14	-0.33
CE152	4.92	-0.19	-0.89	-0.91	0.16	0.57	0.00	-0.18
CE154	1.22	-0.31	-0.49	0.24	-0.00	-0.09	-0.98	0.14
DA222	-0.37	0.94	-0.40	-0.03	0.44	-0.80	0.22	0.21
DA225	0.39	-1.22	-1.37	0.25	-0.26	-3.38	0.56	-0.15
DA226	1.10	-0.48	-0.02	0.63	-3.50	1.47	-0.28	-0.10
DA246	-0.05	-0.40	1.62	2.77	-0.82	0.82	-0.40	-0.38
PO306	-0.25	0.30	1.56	0.91	-0.24	0.76	-0.05	0.59
PO300	0.73	0.57	0.06	-2.13	1.12	1.09	0.09	0.18
PO301	-0.28	0.12	-0.62	-0.20	0.01	0.72	-0.17	-0.58
PO307	-1.78	-0.25	-1.00	-1.17	-0.86	2.06	-0.13	-0.89
HI18	-0.83	-0.43	-0.07	-1.25	-0.29	0.71	-0.37	0.88
HI208	-0.93	0.59	-0.86	-1.68	1.11	1.41	-0.91	0.25
PO304	-0.08	3.22	-0.74	0.19	-0.12	-0.16	-0.31	1.04
DA250	-0.38	4.55	0.29	0.28	-1.92	-0.01	-0.25	-0.16
DA216	-0.33	-0.64	0.03	0.04	-0.50	1.50	0.64	-3.97
DA237	-0.41	0.25	-0.20	0.04	0.05	0.63	-0.26	-0.22
DA219	0.94	0.05	1.74	-1.37	0.86	0.69	-0.56	0.42
PO165	-0.18	0.50	-0.50	-0.26	0.80	0.12	-0.32	0.50
DA221	-0.38	0.04	-0.57	0.56	1.42	0.03	-0.44	0.41
SR138	-0.80	0.92	1.58	-0.11	0.31	-4.03	-0.65	0.45
HE150	-0.44	0.11	-0.11	-0.07	-0.08	0.00	-0.40	0.24
HE148	-0.16	-0.01	-0.43	-0.00	-0.03	-0.07	-0.23	0.05

Assumptions

Before any discussion and interpretations of the results of the analysis can be offered, several assumptions must be made explicit. The validity of the results is partially dependent on the validity of these assumptions:

(1) Biological variables (e.g., age, sex, disease), which are often determinants of status and burial patterning, must be assumed to play little role in the occurrence of artifact types within any tumulus, or the distribution of types between tumuli. To reduce the effects of a potentially faulty assemption here, data transformation was used. Rather than using frequencies of artifacts (values which might be greatly affected by status), these were scaled to rank order data.

(2) Unless it can be shown that a tumulus was disturbed, it is assumed that it dates to the time of, or after, the manufacture of the newest inclusive artifact.

(3) Each tumulus was built within a short span of time (perhaps in a single episode). Thus, all of the artifacts within each tumulus represents a single assemblage of items, not an accretion process. The detailed skeletal analysis by Brock (1980) may shed some light on the validity of this assumption.

(4) Artifacts which typologically predate a tumulus are actually burial accoutrements, either manufactured or curated by the tumulus builders, unless they are found outside or at the base of the tumulus.

Interpretation of Factors

SERIATION

Six of the factors may be associated with time and two others tentatively scale this same dimension. Factors 2, 3, 5, 6, 8 and 12 are created by the co-occurrence of artifact types which have previously been used in the Ozarks as temporal indicators. Factor 16, with its high loading by only one variable (sand-tempered pottery), must be examined with some caution. Likewise, Factor 10 can be used for scaling along a temporal dimension, but is somewhat ambiguous due to several intermediate to low loadings.

Factor 6, with a high loading on Afton points and intermediate loadings on points within the Snyder's group and cut wolf-maxillae is indicative of the earliest period represented by the tumuli. Similarly, in Factor 2, Table Rock Stemmed points load highly and Cooper-like corner-notched and Rice

Side-Notched load intermediately. Both Afton and Table Rock Stemmed points are diagnostic of the late Archaic period. Co-occurring with these early points are artifacts diagnostic of the Woodland period. Both Snyder's group points and cut wolf maxillae are Middle Woodland traits; these are horizon markers in the Midwest. Cooper points are found in late Middle Woodland contexts in Oklahoma (Purrington 1971) and the Kansas City area (Shippee 1967). The formally similar Cooper-like points and Rice Side-Notched points in the present sample likely appear during the late Middle Woodland time period, as well.

A second general time period in Midwestern prehistory which has particularly characteristic artifact forms is the Mississippian period. Around A.D. 1000, small triangular points with multiple notches and shell-tempered pottery came into use. Three factors (3, 5, 12) in the present analysis seem to have been formed on the basis of Mississippian period artifact assemblages.

In Factor 3, three forms of multiple-notched triangular-bladed arrows (Huffaker, Washita, and Harrell) load highly. Factor 5 contains high loadings of Keota arrows and limestone-tempered cord-marked pottery. Both forms of shell-tempered pottery (cord-marked and smooth) load intermediately on Factor 12. These three factors seem to identify the late prehistoric part of the temporal dimension represented in the sample.

A third period in southwest Missouri prehistory may be identified on the basis of Factor 8. White trade goods, Delaware-like points, and Fresno points characterize this factor. The type name, "Delaware," may actually be a misnomer, since darts of this form have been designated to an Archaic period in Oklahoma, where the point was named (Purrington 1971). However, that points of this general form occur in proto-historic context in Missouri is undeniable. All three of these forms were prevalent in the proto-historic Big Osage and Little Osage sites examined by Chapman (1959). On the basis of white trade goods, the sites scoring highly positive on Factor 8, can be dated to no earlier than around A.D. 1650.

Such relative dating rests on the ability to show that these typologically late artifacts were not intrusive. In some cases there is some question about the context of the trade goods (see Wood 1967: 115-116). However, the placement of trade goods in at least one tumulus (BE128) was unquestionably during actual body interment. Therefore, it seems likely that other tumuli date from the historic period.

Two other factors (10 and 16) are tentatively associated with a temporal dimension. Factor 16, on which sand-tempered pottery loaded highly seems to be another indicator of a fairly early period in the sequence of tumulus building. Sand has often been thought to be the dominant temper material in the earliest Midwestern pottery. As no other variables load highly on this factor, such a conclusion is difficult to support.

There is some difficulty in interpreting Factor 10. The highest loading is of Haskell, multiple-notched arrow points. The presence of these Mississippian period artifacts might ordinarily support a temporal interpretation of this dimension. However, there are also intermediate loadings of Snyders group and Late Woodland category points on this factor. Formation of the factor may have been dependent upon several sites <u>not</u> having certain categories of artifacts. Indiscriminant use of this factor for interpretations could lead to spurious conclusions.

The factor scores (Table 5) generally support the conclusion that seven factors scale the tumuli along a temporal dimension. Table 6 is presented as a schematic representation of how various tumuli scored on these factors. The sign (+ or -) below the factor number indicates the sign of the high loadings on the variables in each factor. Each tumulus which scored $\geq |1.00|$ on each factor is tabulated as + or -, depending on the sign of its factor score. Thus, tumulus CE122, with a + on Factor 2, on which Table Rock Stemmed, Cooper and Rice Side-Notched loaded positively, contained several of those types. On the other hand, CE122 scored negatively on Factor 6, indicating that its absence of Afton and Snyders points contributed to the formation of that factor. Similarly, on Factor 12, a factor with high <u>negative</u> loadings, CE122's high <u>positive</u> score indicates a significant <u>absence</u> of shell-tempered pottery.

Of the twenty-nine tumuli which scored highly on at least one of the time-sensitive factors, twenty-seven score on factors within only one postulated time period. The two tumuli which have ambiguities are BE6-2 and BE6-3. The first scores highly on factors from all three periods, and BE6-3, on the earliest and latest periods.

There are two possible explanations for such scores. The first is that these tumuli, the most elaborate and largest in the sample, were used during all of the three postulated periods. Although possible, this is unlikely, given that there is no evidence for different burial episodes and that the artifacts diagnostic of different periods are not stratified or spatially clustered.

TABLE 6

Schematic of Scoring Incidence of Tumuli on Temporally Significant Factors

PERIOD	WOODLAND			MISSISSIPPIAN			CONTACT
FACTOR	16	6	2	3	12	5	8
DIRECTION OF LOADINGS	-	+	+	+	-	-	+
TUMULUS							
HE139	-						
HI30a	-						
CE122		-	+		+		
BE3		+					
BE117		+					
SR111	+						
HI149	-	+					
BE6-3	+		+				+
CE104	-						
CE148			+			+	
HI209	+		+		+		
BE136			+		+		
PO304	+		-				
BE6-2	-		+		-		+
HI208				+	-	-	
CE123				+	+		
HI30	+			+	-		
PO300					-	-	
DA246					+		
PO307					-		
DA219					-		
HI18					-		
DA226							+
DA221							+
PO301							+

TABLE 6: Continued

Schematic of Scoring Incidence of Tumuli on Temporally Significant Factors

PERIOD	WOODLAND			MISSISSIPPIAN			CONTACT
FACTOR	16	6	2	3	12	5	8
DIRECTION OF LOADINGS	-	+	+	+	-	-	+
TUMULUS							
DA222						+	
PO306						-	
DA237						-	
DA225						-	

The second possible explanation for high scores on factors of two or three periods involves processes of culture change. Change through time usually suggests replacement of some artifact types or styles gradually, by others; not quick, discrete changes. Tumuli BE6-2 and BE6-3 seem to be the two most obvious examples of such retention of tool forms through time, with addition of newer types to the cultural inventory. That this pattern manifests itself so strongly in the factor analysis on these two tumuli is due to the fact that BE6-2 and BE6-3 contained large numbers of temporally diagnostic artifacts. A closer examination of the patterning of artifacts in other tumuli with smaller numbers of inclusions will support the gradual change explanation.

The fact that a tumulus does not score highly on any one factor does not preclude the presence in the tumulus of some artifacts characteristic of that factor. Thus, a digression from interpretation of strictly the high factor scores is informative. A return to original frequencies shows that tumuli scoring highly on factors of the last two time periods often do have artifacts characteristic of the earliest period in small quantities. Similarly, tumuli scoring highly on the contact period factor possess characteristics of the Mississippian period. The reverse is not true, however.

Another similar line of evidence supports the notion of a gradual change in the pattern of frequencies of artifact types through time. Table 7 presents those tumuli which did not score highly on any of the seven postulated temporal factors. The frequency of occurrence in these tumuli of artifact types which had the highest loadings on the seven temporal factors is given. It is fairly obvious, given the low frequencies, why these tumuli did not score highly on the seven factors. (The one exception is DA216 with 11 Huffaker points, giving it a rather high score +.95 on Factor 3). In fact, of the twenty-one tumuli listed, four contained none of the temporally diagnostic artifacts. Six of the others had artifacts characteristic of factors in more than one period.

A tentative and gross seriation of the tumuli is presented (Table 8). It is based on factor scores of the tumuli on the seven postulated temporal factors, as well as information extracted from Factor 10 and frequencies from Table 2. Ranking of tumuli within each time period was fairly arbitrary and will be subject to revision. The two tumuli in the Late Archaic group were not included in the factor analysis, as they included only one of the variables: Afton points. They are placed early in the sequence on that basis. Tumuli scoring highly on Factors 2, 6, and 16 were placed in

TABLE 7

Tumuli Not Scoring Highly on Temporally Sensitive Factors:
Frequency of Temporally Diagnostic Variables

Tumulus	Sand-temper pottery	Afton	Wolf maxilla	Snyders	Table Rock Stemmed	Cooper-like	Rice Side-Notched	Huffaker	Washita	Harrell	Shell-temper pottery	Keota	L.S.-temper cordmark pottery	Trade goods	Fresno	Delaware
BE6-1	-	-	-	-	-	6	15	-	-	-	1	-	-	-	-	-
BE6-4	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-
BE112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE128	-	-	-	-	-	1	4	-	-	-	-	-	-	1	-	-
BE118	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
BE135	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
CE190	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
CE198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA201	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
HI30c	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
SR135	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
SR141	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-
CE150	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-
CE152	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CE154	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
DA250	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-
DA216	1	-	-	-	-	-	5	11	-	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR138	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-
HE150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
HE148	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 8

Tentative Seriation of Tumuli

LATE ARCHAIC

HI135*
PO305*

WOODLAND (pre-arrow)

SR111
SR141
BE136
CE122

WOODLAND (with arrows)

CE190
HI30c
HI30a
HI149
DA201
HE139
BE3
HI209
BE118
SR135
DA246
BE117
CE148
SR138
CE104

MISSISSIPPIAN

BE6-1
DA216
DA291
CE123
PO300
DA250
HI18
BE135
BE6-4
PO304
CE152
PO307
PO306
DA237
DA225
HI30
HI208

LATE MISSISSIPPIAN

CE150
CE154
HE150
DA226

CONTACT

BE128
BE6-2
BE6-3
PO301
DA221

SITES WITHOUT TEMPORAL INDICATORS

BE112
CE198
PO165
HE148
DA222

*not included in the factor analysis

a "Woodland" category. These were then ranked on the basis of frequency of occurrence of Scallorn arrowpoints. The four tumuli without arrow points may be earlier in the sequence, as the adoption of the bow and arrow is presumed to have come relatively late in the Woodland period. Those tumuli scoring highly on Factors 3, 5, and 12 were assigned to a "Mississippian" category and are unranked within it, with one exception. A "Late Mississippian" category was formed to include those tumuli with a high frequency of Fresno arrow points. Although that variable loads highly with White trade goods on Factor 8, presence of Fresno points alone is not indicative of White contact. Rather, Fresno points may be diagnostic of the latest pre-contact period in southwest Missouri; a trait which may have persisted into the contact period. Only those tumuli containing White trade goods were included in the final "Contact" category.

The best test of this tentative seriation will be through radiometric determination methods. A small number of samples have been submitted for Carbon-14 and thermoluminescence tests. The results of these are presented (Fig. 6 and Table 9). The C-14 dates were run at the Geochron and University of Michigan laboratories. The results are described in Crane and Griffin (1968: 84-86) and Wood (1976b: 311-312). The thermoluminescence determinations were made at laboratories at the University of Missouri-Columbia, under the direction of R. Rowlett. The results are presented by Mandeville in Appendix E of this report. The C-14 dates from DA226 and BE3 were averaged, following Long and Rippeteau (1974). Similarly, the TL dates from two samples at PO306 were averaged.

A few general statements can be made about the relationship between the absolute dates and the tentative seriation. First, the TL date on an Afton point from HI135 supports its placement in the Late Archaic period, perhaps placing the beginning of this mortuary complex in a pre-Woodland context in southwest Missouri. The two C-14 dates of 520 BP and 385 BP for HI135, at first inspection, seem impossibly late. Second, as expected, those tumuli categorized as "Mississippian" and "Late Mississippian" do not date after A.D. 1500, implying that they were built before the first White contact in the area.

Two other areas of vital importance for confirmation or rejection of the seriation must await further absolute dates. First, it is not known how long into the White contact period the mortuary complex continued. None of the five tumuli categorized as "Contact" tumuli have been dated. Second, the "Woodland" and "Mississippian" categories remain ambiguous. Only two tumuli, CE148 and BE3, from the "Woodland" category were dated. The first may be dated correctly, thereby making its placement in the "Woodland" period suspect.

TABLE 9

Absolute Dates from Tumuli

Site	Sample	TL Date	C-14 Date	Material Dated	Reference
PO306	4	643 BP±30		Cupp point	Mandeville, Appendix E
PO306	41	370 BP±30		Reed point	Mandeville, Appendix E
PO306	Average	507 BP±30			
DA225	49	997 BP±49		Flake	Mandeville, Appendix E
PO307	55	807 BP±40		Flake	Mandeville, Appendix E
HI135	18	2864 BP±427		Afton point	Mandeville, Appendix E
DA226	GX-678		485 BP±90	Woven bag	Wood 1976: 312
DA226	GX-677		840 BP±75	Chenopodium	Wood 1976: 312
DA226	Average		688 BP±57		
CE150	M-1932		860 BP±100	Charred corn	Crane and Griffin 1968
CE148	M-1902		950 BP±120	Charcoal	Crane and Griffin 1968
CE152	M-1967		1560 BP±140	Charred nuts	Crane and Griffin 1968
BE3	GX-559		1855 BP±215	Charred bone	Wood 1976: 311
BE3	GX-570		2175 BP±380	Charred bone	Wood 1976: 311
BE3	Average		1935 BP±215		
HI135	GX-558		520 BP±135	Unburned bone	Wood 1976: 311
HI135	GX-569		385 BP±105	Unburned bone	Wood 1976: 311
HI135	Average		439 BP±83		

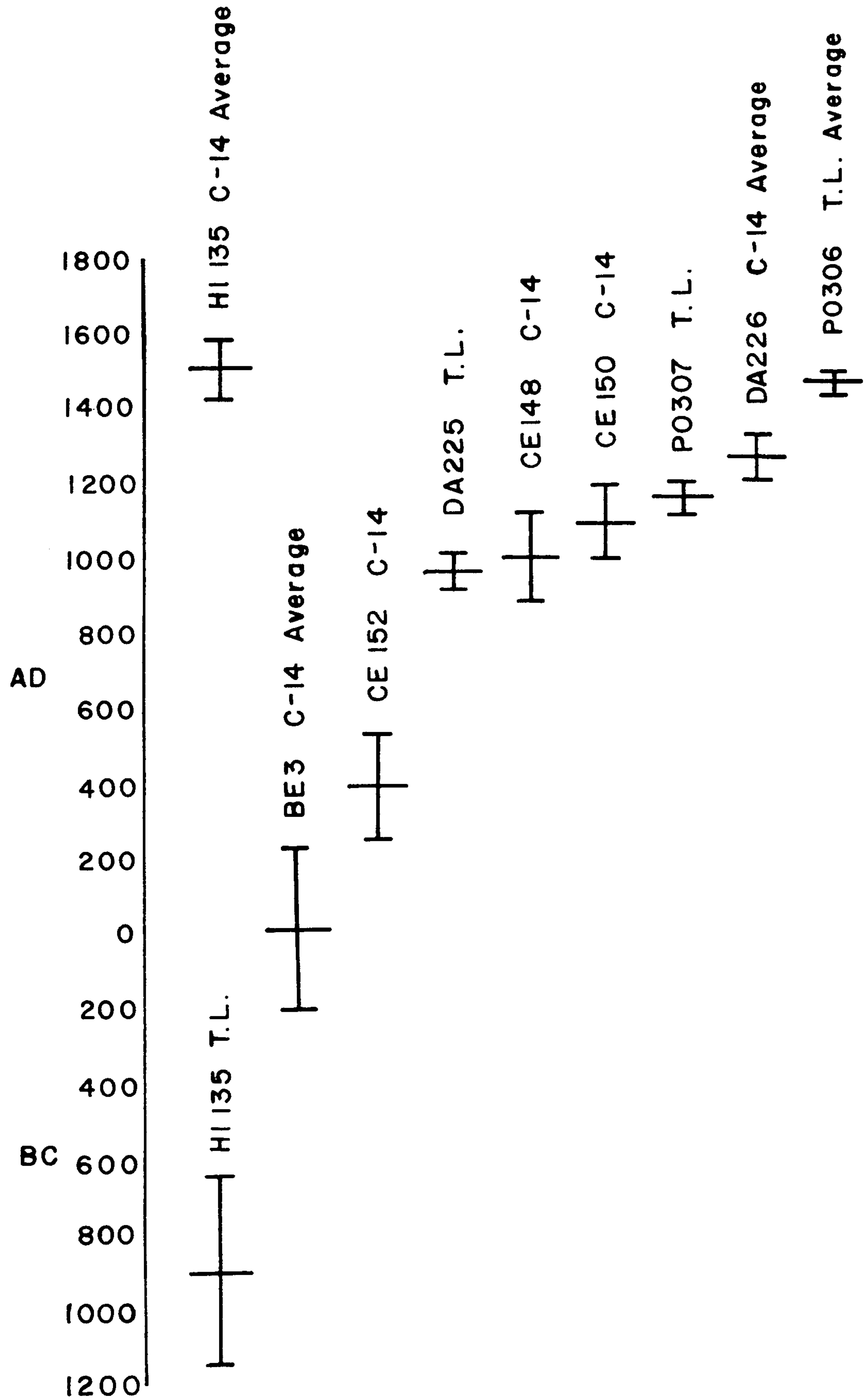

Figure 6. Range of absolute dates from tumuli.

The later tumulus has a date which is probably too early. Although it contains several "Hopewellian" artifacts, the Scallorn arrow points in it would make a date of A.D. 700 more consistent with its cultural inventory. The exact relationship between tumuli in the "Mississippian" and "Woodland" categories must await further dates, particularly of "Woodland" sites. Several more samples are currently under analysis for TL determinations. These should also allow comparisons between the two methods of dating and confirmation or rejection of suspicious dates.

The eight or nine factors which cannot be interpreted as scaling the tumuli along a temporal dimension are presented in Table 10. The tumuli are presented in order, based on the tentative seriation. For each non-temporal factor, the high positive and negative scores are noted with a + and -, respectively. This schematic shows that the patterning of these high scores is fairly random across the temporal dimension. These factors are probably scaling the tumuli along a spatial or cultural dimension.

Spatial Dimensions

Two of the remaining eight factors appear to represent spatial clustering of certain artifact types. Four tumuli score highly on Factor 1. These are all within the Stockton Reservoir area (see Fig. 7). Neither of the variables loading highly on this factor — Cupp points and stone pipes — seem particularly temporally diagnostic. Intermediate loadings on several types of bone artifacts may represent a degree of preservation not found in other areas. Most interesting, of the intermediate loadings, are those on corn and shaped manos. The Stockton tumuli are the only ones with remains of corn, thereby distinguishing them, at least spatially.

The time depth and extent of dependence on corn is not clear from the artifact assemblages. Based on artifact inventories, there are two tumuli, CE148 and DA246, which were classified as "Woodland." However, a Carbon-14 date from CE148 (950BP±120) places it within a Mississippian time period. More absolute dates should clarify the situation, but it is clear that corn was available in southwest Missouri at least by sometime around A.D. 1000.

The extent of utilization of corn as a food source is impossible to discern from tumulus artifact assemblages. However, analysis of skeletal materials (Brock 1980), comparing remains from tumuli with corn to those without, shows some differences. She has postulated that while corn was probably a component in the diet of those individuals buried in tumuli with corn, it was a food supplement, not a replacement for other forms of gathered resources.

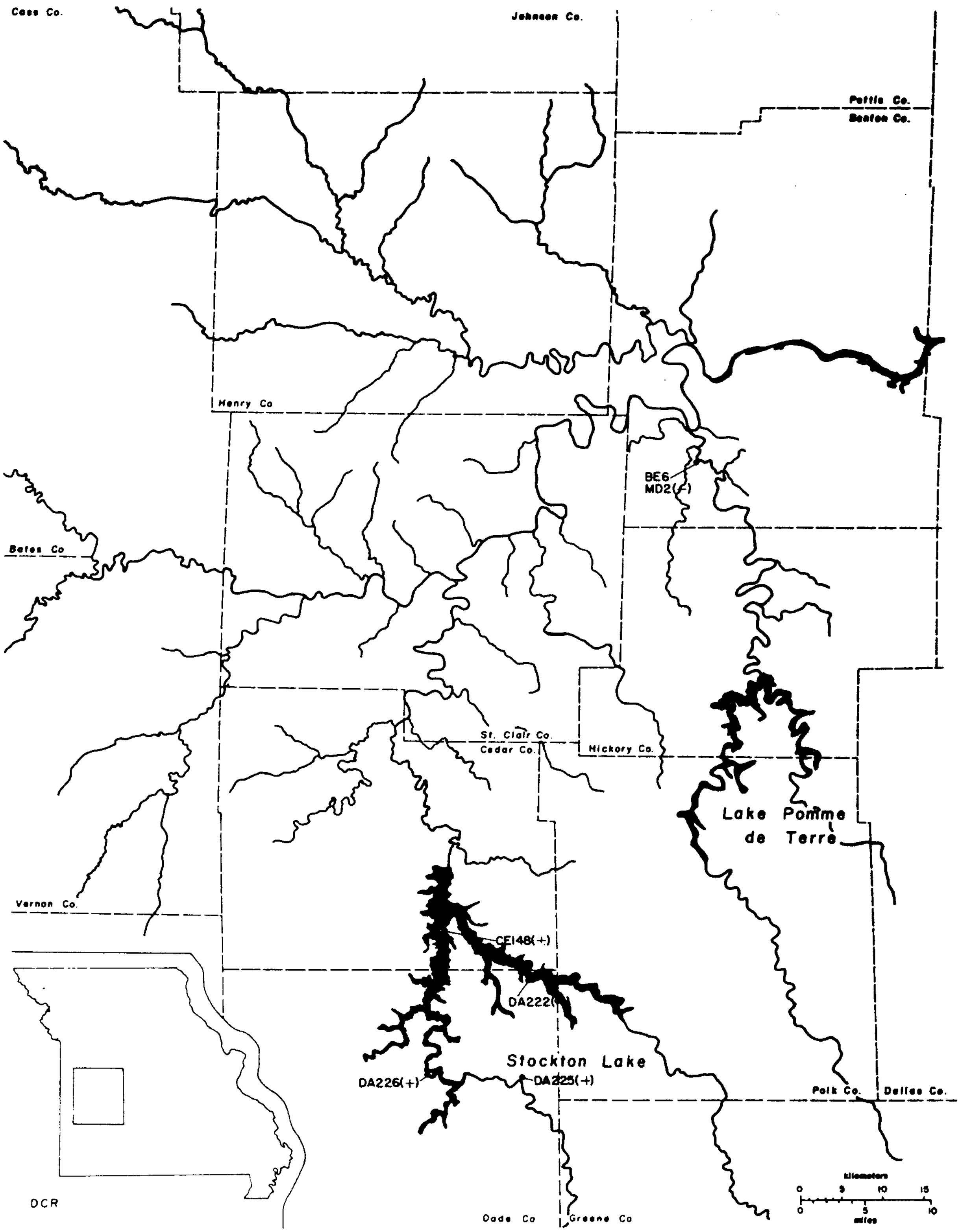

Figure 7. Spatial distribution of Factor 1.

TABLE 10

Factor Scores of Tumuli on Non-temporal Factors

Tumulus	Non-Temporal Factors 1	4	7	9	10	11	13	14	15
Woodland Pre-arrow									
SR111					+				
SR141									
BE136									
CE122							+		
Woodland With Arrows									
CE190									
HI30c									
HI30a									
HI149					–				
DA201									
HE139									
BE3									
HI209							–		
BE118									
SR135			+						
DA246			–			+			
BE117					–				
CE148	+						+		
SR138						+		–	
CE104		–						–	
Mississippian									
BE6-1							+		+
DA216			+					+	
DA219						+			
CE123			–	+				–	+
PO300							+	+	
DA250							–		
HI18					–				

TABLE 10: Continued

Factor Scores of Tumuli on Non-temporal Factors

	Non-Temporal Factors								
Tumulus	1	4	7	9	10	11	13	14	15
BE135									
BE6-4					+				
CE152				+					
PO307			–	–		–		+	
PO306			–			+			
DA237			–						
DA225	+				–	–		–	
HI30				–	–				–
HI208							+	+	
Late Mississippian									
CE150				+		+			
CE154		–		+					
HE150									
DA226	+			+			–	+	
Contact									
BE128									+
BE6-2	–		–		+		–	–	
BE6-3		–	+	–		+	–		+
PO301									
DA221							+		

Factor 9, with high loadings of smooth limestone-tempered pottery and groundstone celts, is also largely explained by high scores of tumuli from the Stockton Reservoir area (see Fig. 8). Only BE6-4, which scores highly, is from the more northern region. Temporally, the high scoring tumuli fall into the "Mississippian" category. This factor may represent a geographical area whose inhabitants possessed a certain distinct mode of pottery manufacture during the Mississippian period.

Other Dimensions

The remaining six factors appear to be describing variation of two types: (1) infrequently occurring artifact types, common to only a few tumuli; and (2) variation common to many tumuli and neither spatially nor temporally confined.

Factor 4 and Factor 15 are difficult to explain due to the low frequency of the artifacts which load highly, as well as the small number of tumuli scoring highly on them (see Figs. 9 and 10). Gary and McConkey points load highly on Factor 4 and Standlee points, variants of Rice Side-Notched points, and calcite-tempered pottery load highly on Factor 15. Factor 4 may be explained by cultural contacts to the southwest, as Gary points are the dominant dart form in Spiro Focus sites (Purrington 1971) and McConkey points are more prevalent in northeastern Oklahoma than elsewhere. Both Factors 4 and 15, however, may be explained by chance inclusion during the burial of artifact forms commonly found in habitation sites. In fact, the low frequency of both Standlee and Gary points in tumuli is difficult to explain given their ubiquity in other sites in the region (see Roper 1977).

The remaining four factors (7, 11, 13, and 14) describe patterns of fairly common mortuary inclusions in the southwest Missouri tumuli. There seems to be no spatial (see Fig. 11) or temporal meaning in the occurrence of antler cylinders, which load highly on Factor 13. This artifact form is common in sites throughout the Midwest during all periods. Factor 13 may represent either chance inclusion as a grave good or differential preservation.

Factor 14, with F-drills loading highly, is also describing a fairly common occurrence in the tumuli (see Fig. 12). Given the cultural affiliation of these small drills with Spiro Focus sites in northeastern Oklahoma (Purrington 1971), F-drills may be used cautiously as a horizon marker. It is interesting to note that the tumuli scoring highly on Factor 15 fall either late in the "Woodland" category sequence or in the "Mississippian" category, with the exception of BE6-2.

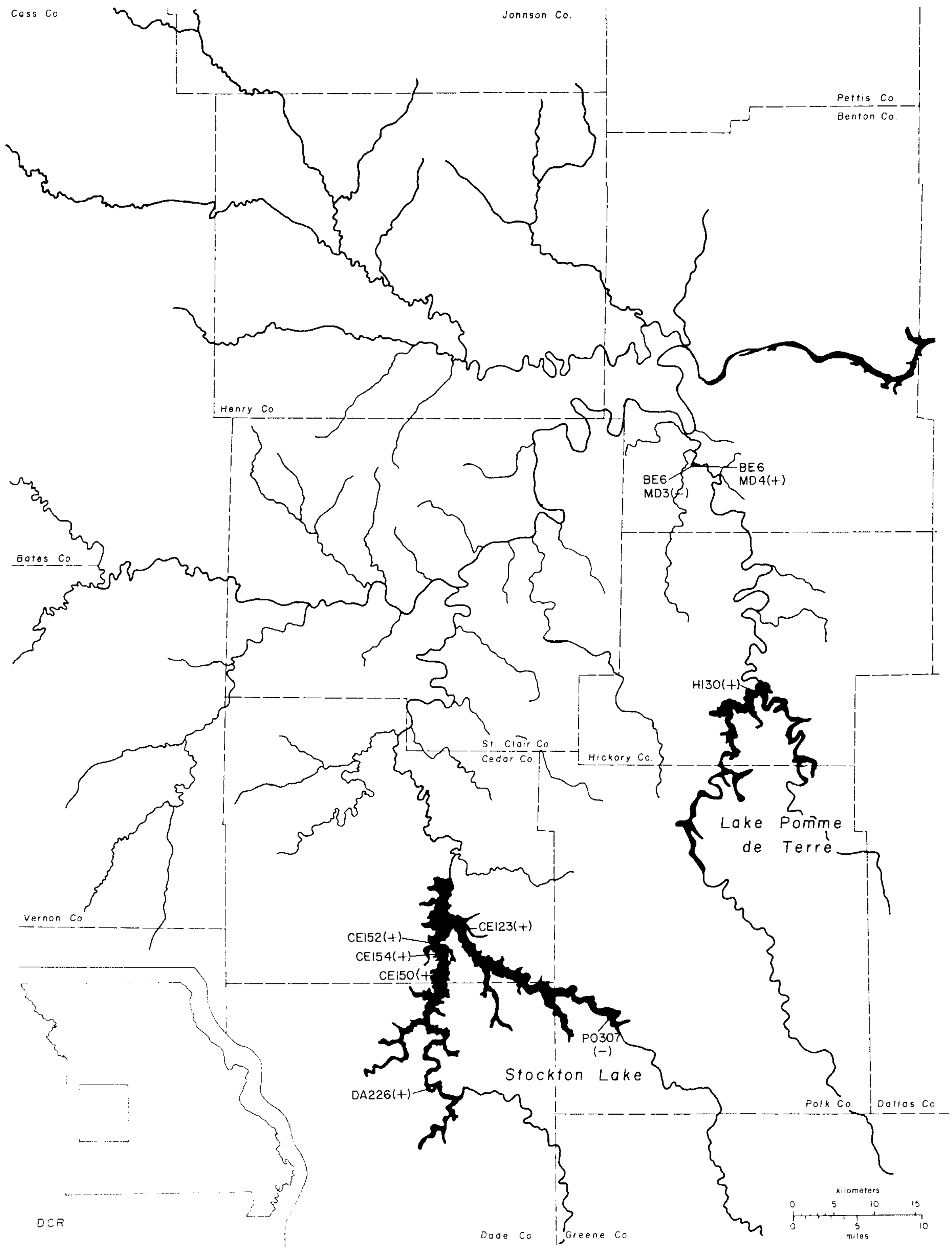

Figure 8. Spatial distribution of Factor 9.

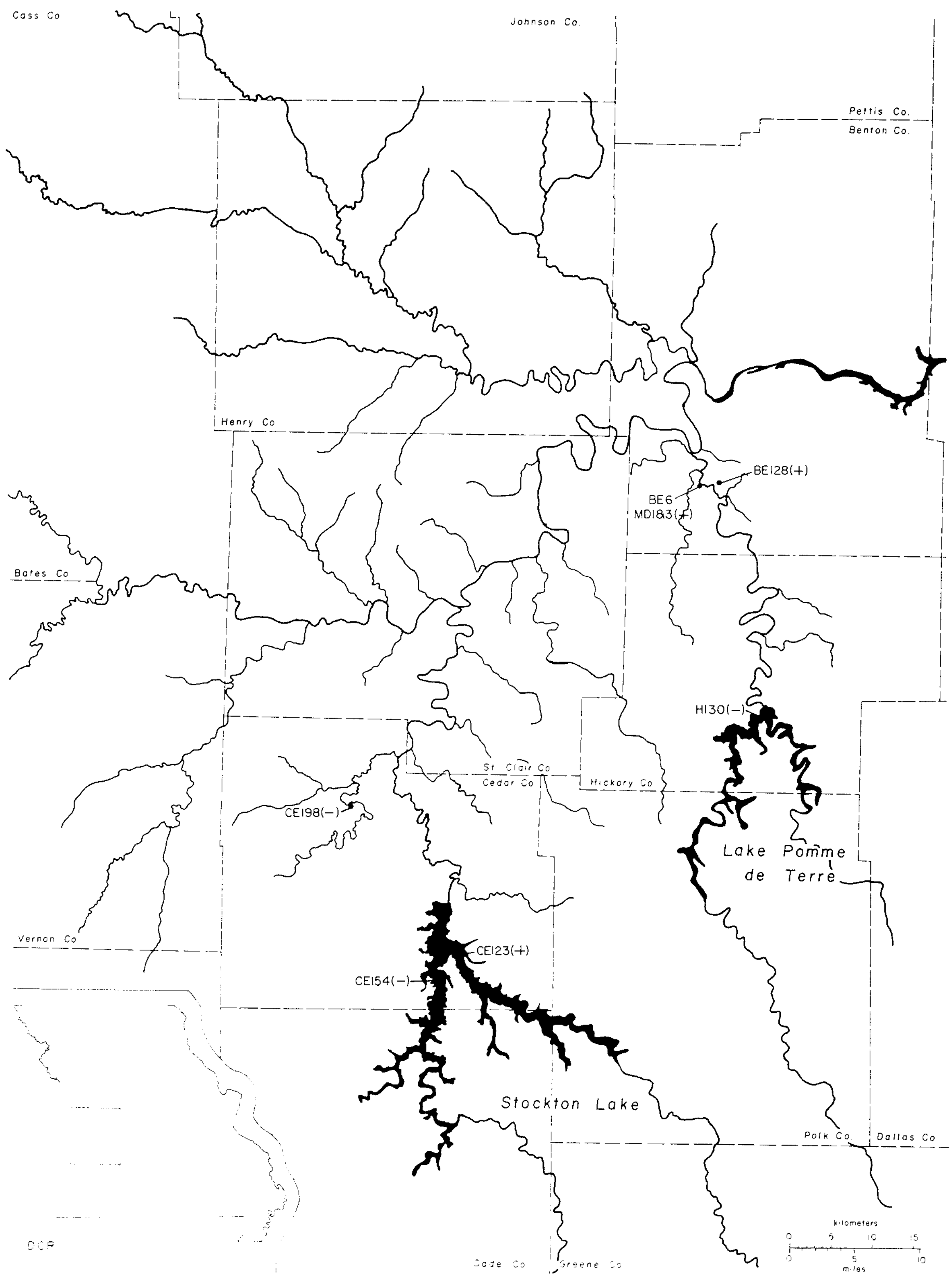

Figure 9. Spatial distribution of Factor 15.

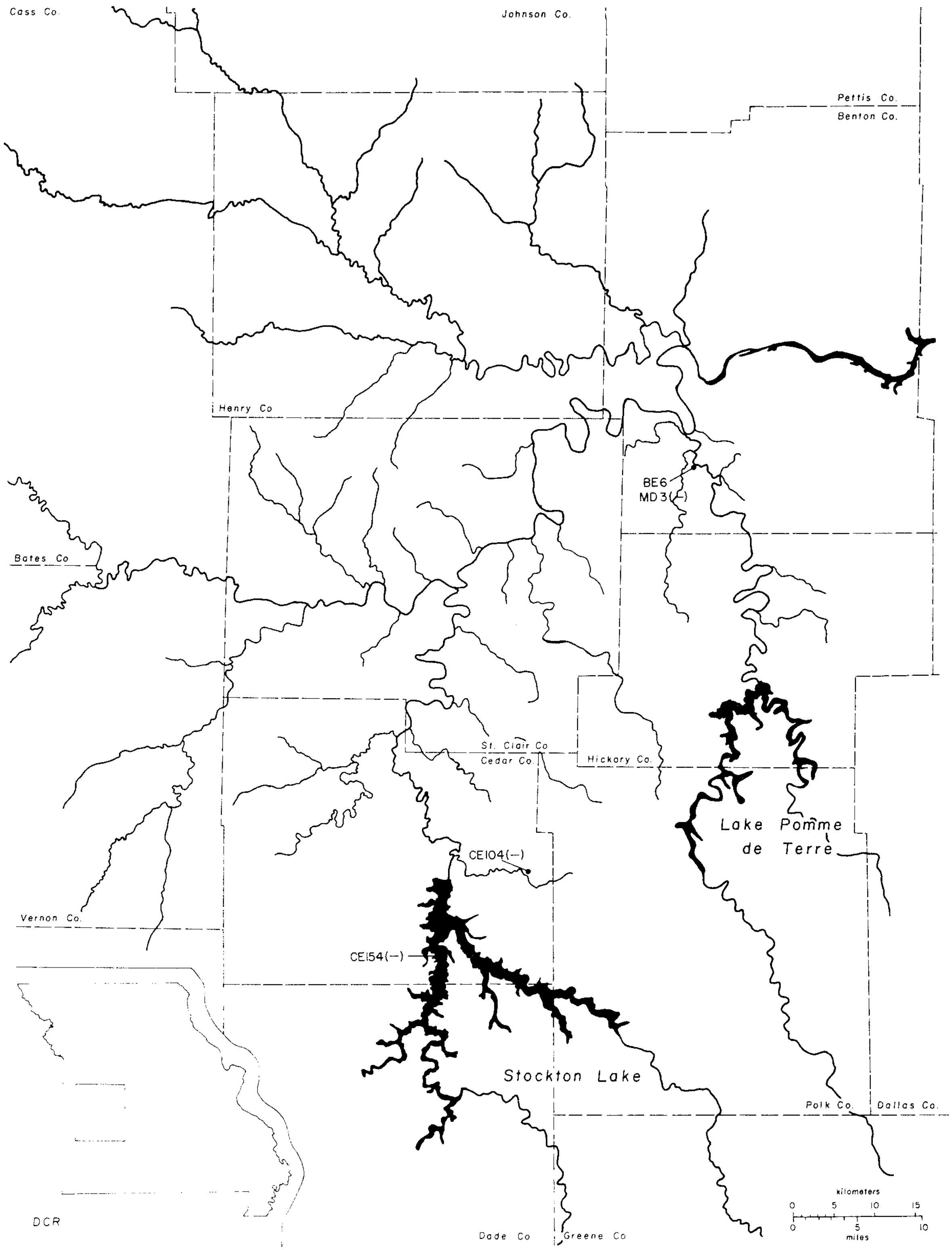

Figure 10. Spatial distribution of Factor 4.

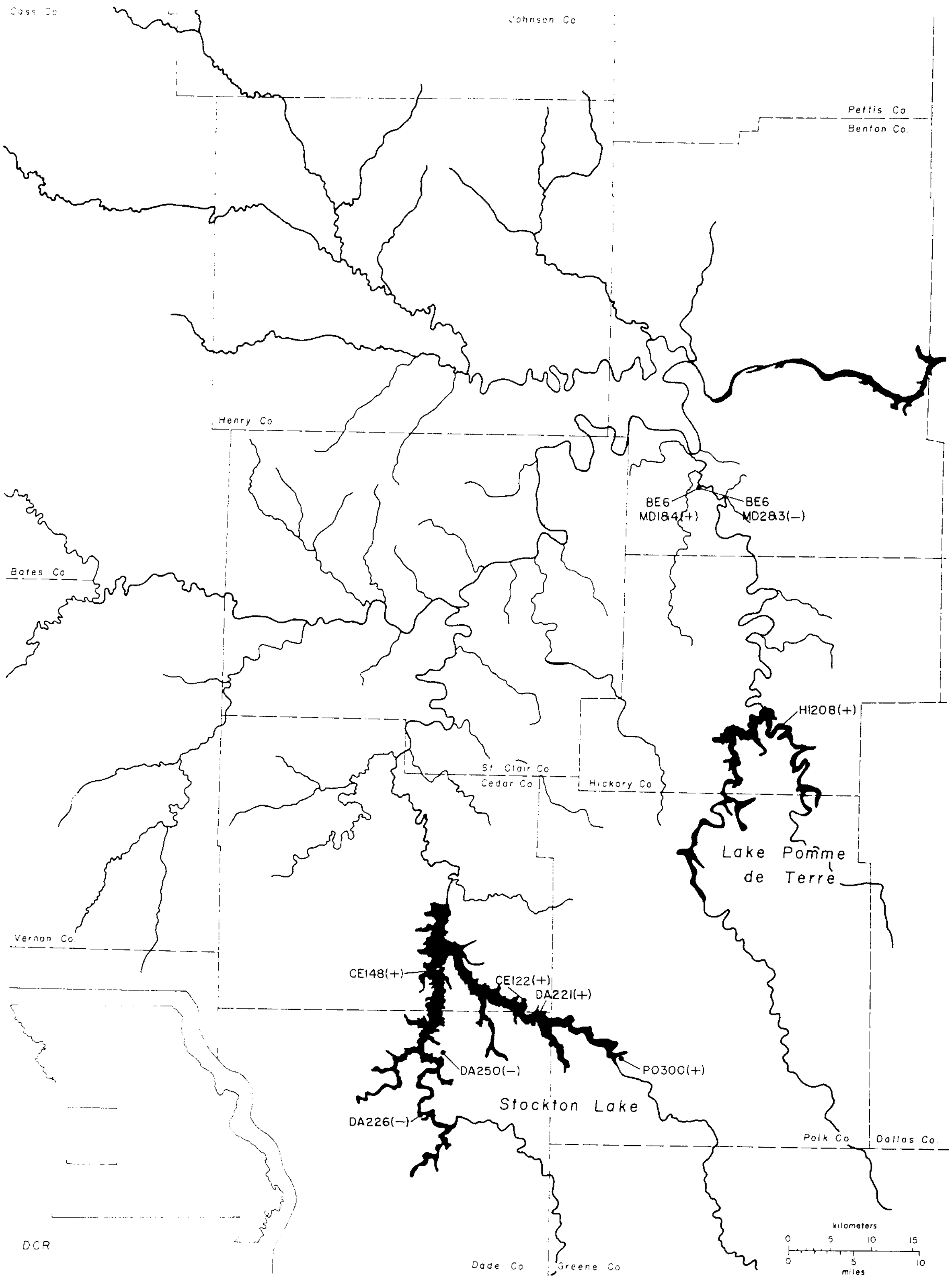

Figure 11. Spatial distribution of Factor 13.

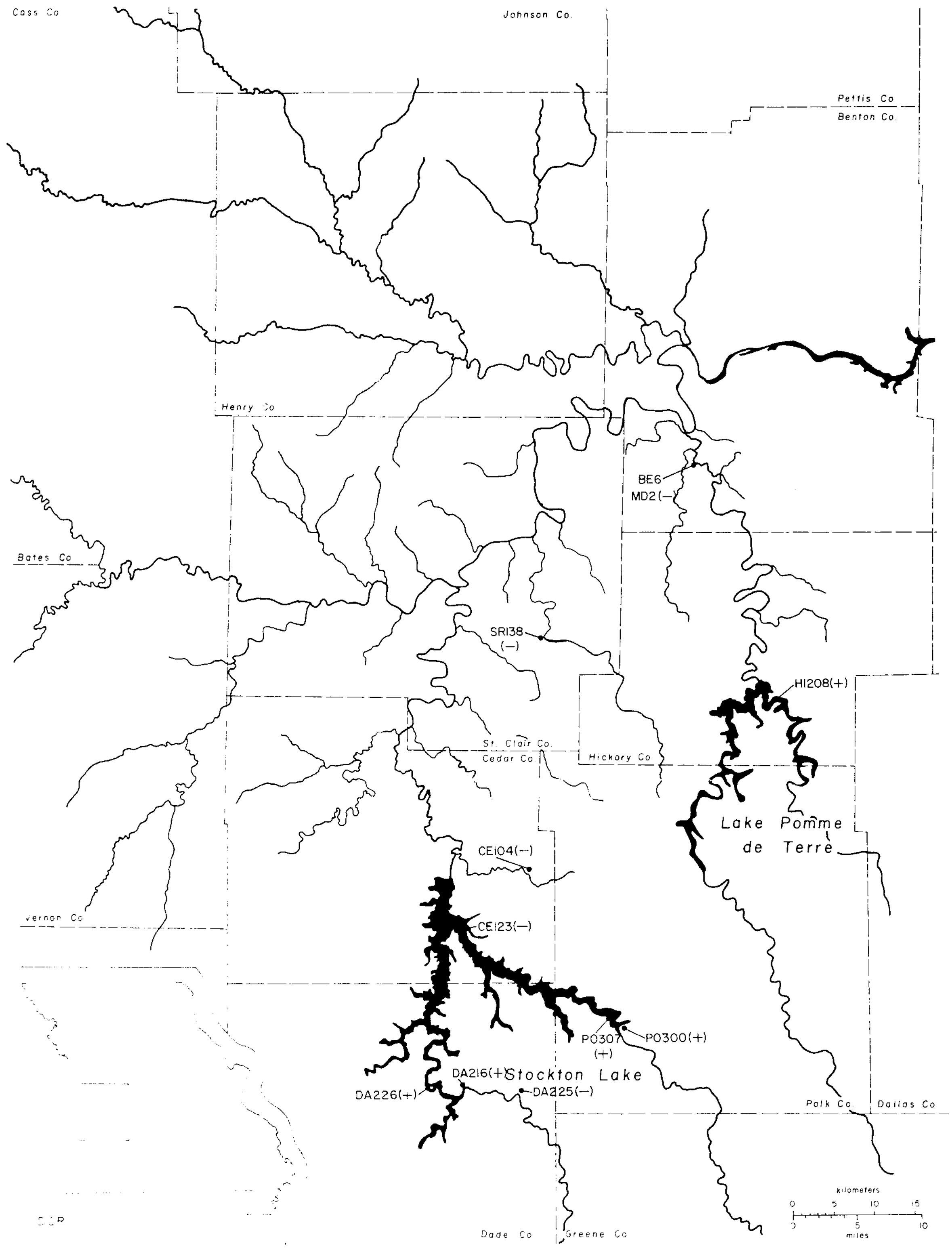

Figure 12. Spatial distribution of Factor 14.

The last two factors to be considered (7 and 11) are both characterized by the high loading of shell beads. Factor 11 (see Fig. 13) is difficult to interpret due to several intermediate loadings. One variable with an intermediate loading is Reed arrow points. These points are fairly common on the Plains in burial context, as are the mollusk shell beads. This factor may be interpreted as evidence of cultural contacts with groups to the west.

Factor 7 is much easier to interpret, since it has an intermediate loading of conch gorgets. This factor is clearly describing the importation of marine shell from outside the Ozarks, probably from the Gulf Coast. The occurrence of marine shell is widespread in the Midwest, from the Archaic to the historic period. It is possible that the shell came to southwest Missouri indirectly, through trade with other Midwestern groups. However, the presence of unworked shell argues for fairly direct trade from the Gulf Coast region. The tumuli scoring highly on Factor 7 are neither spatially (see Fig. 14) nor temporally confined. This, combined with the fact that several other tumuli include marine shell in smaller quantities, indicates that such trade must have been extensive and of considerable time depth.

Cluster Analysis of Factor Scores

To aid in the interpretation of the relationship between the tumuli in the sample, a cluster analysis of unrotated factor scores was performed. Factor scores, being a measure of how much each tumulus accounts for the creation of a factor, should permit mapping of those tumuli which are most similar, in terms of the dimensions described by the factor analysis. Thus, if the artifact assemblage at any one tumulus is determined mainly by its spatial proximity to other tumuli, it should cluster with them. Similarly, if similarities in artifact inclusions are dependent mainly on cultural contact between populations during a given time period, those tumuli from the "Woodland" period, for example, should cluster. However, if neither of these types of clusters occur, it may be an indication that there was a generalized pattern of mortuary inclusions throughout the area, and through time, which mask patterns characteristic of specific regions or periods. Such a pattern would exist if there were trade of ideas or items between spatially separate groups, or if there were continuity in the cultural inventory through time.

A uni-dimensional map (phenogram) was produced, using the Numerical Taxonomy System program (Rohlf, Kishpaugh, and Kirk 1972). The unrotated factor scores were weighted by the eigenvalues of each factor and clustered using the unweighted pair group method of arithmetic (UPGMA) algorithm. Such a technique weights each variable equally and permits

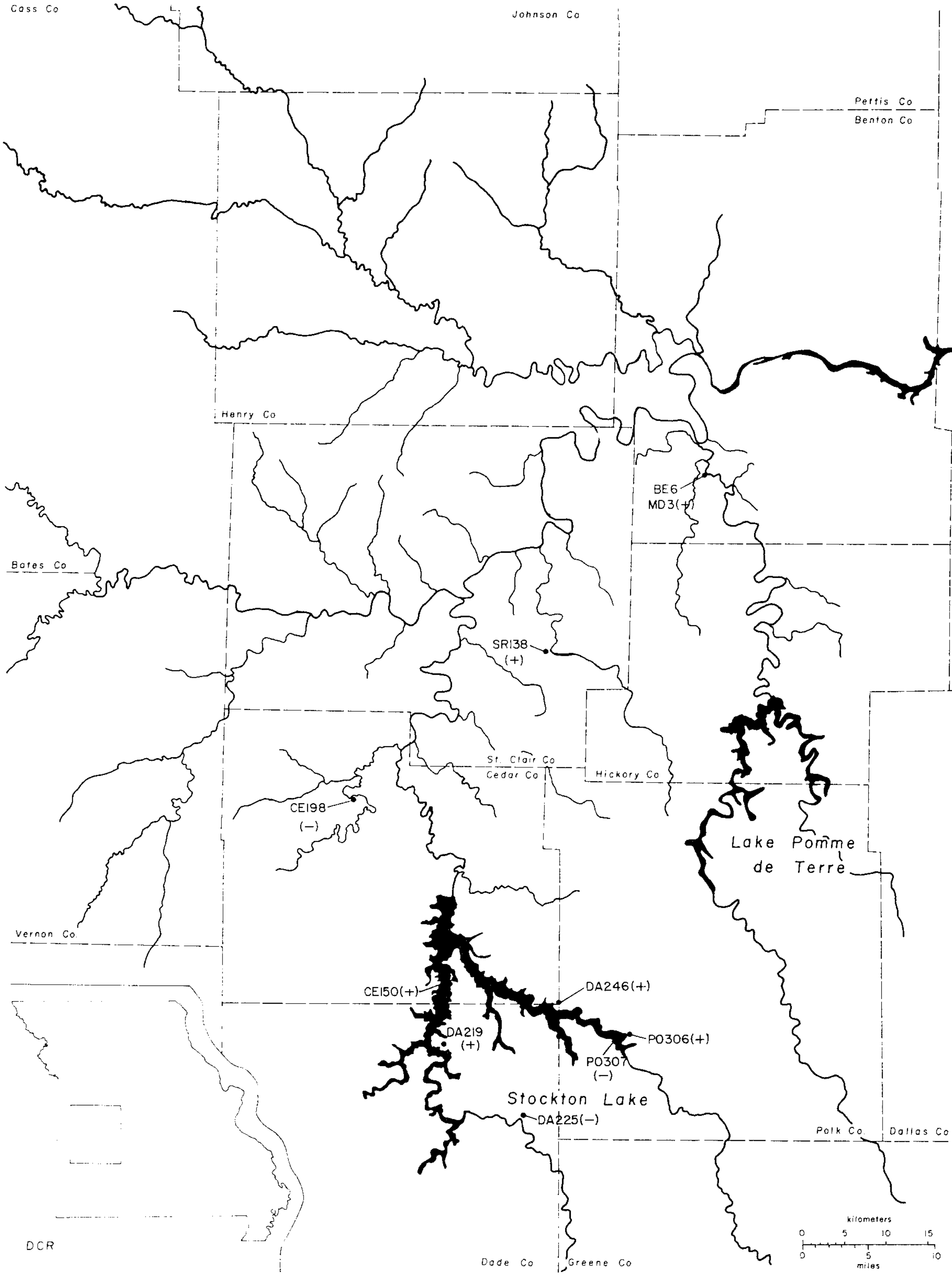

Figure 13. Spatial distribution of Factor 11.

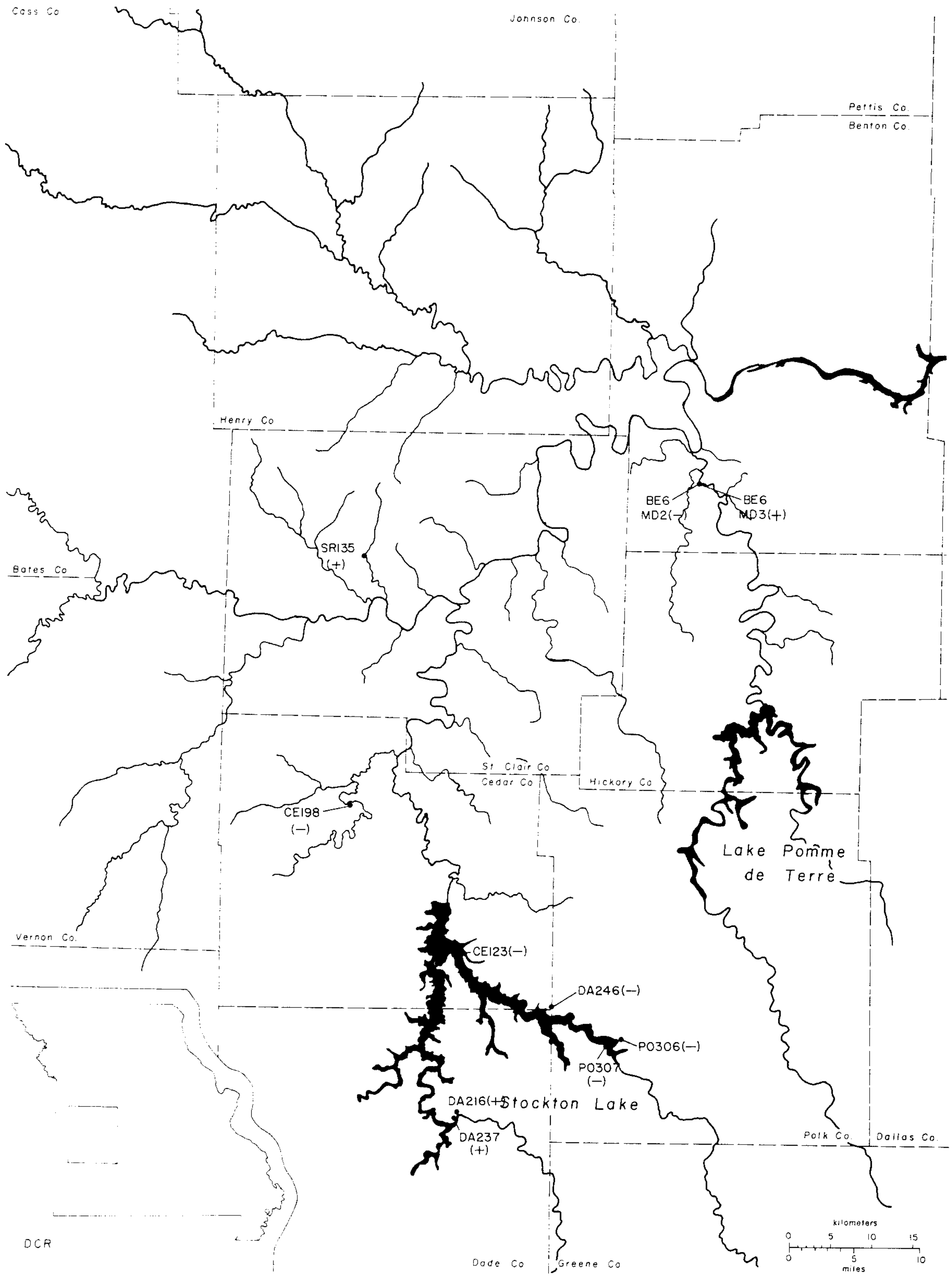

Figure 14. Spatial distribution of Factor 7.

mapping of the sixteen factors in what is, approximately, their original space. The phenogram is presented in Fig. 15. The cophenetic correlation was calculated to be .906, indicating that one dimensional space is fairly adequate for representing the variability in the sample.

It can be seen from Figure 15 that much chaining has occurred in the mapping and that no tight clusters were created. Analysis of the relationship between the postulated seriation and cluster membership has been facilitated by labelling, in Figure 15, of each tumulus to its temporal category. The tighter clusters tend to be tumuli from the "Woodland" periods. However, many of the tumuli from the later periods have artifact assemblages more like these "Woodland" tumuli, than like tumuli in their own temporal category. It can be generalized, then, that, across the sixteen dimensions, the vWoodland" tumuli are more like one another than are the later tumuli. The variability, however, does not define, or distinguish between, temporal groupings of tumuli. What is most apparent from the chaining in the clustering is that the sample is extremely heterogeneous during all periods, but increases greatly through time.

A similar pattern of association can be seen spatially. The tighter clusters occur between tumuli in the non-Stockton Reservoir areas. However, several of these Cedar, Polk, and Dade county tumuli are more like the northern tumuli than they are like those in Stockton.

Some spatial and temporal patterning is shown in the phenogram. For example, there is a cluster of three tumuli (HI30, HI18, and HI208) which are spatially clustered and assigned to the "Mississippian" period. However, what becomes clear from the cluster analysis is that there are factors which minimize strong patterns of association between groups of tumuli, and point out unique characteristics of each tumulus. It seems that this general cultural pattern — which masks differences between tumuli — operated most strongly in the earlier periods and that, generally, patterns of artifact inclusions become more unique during the"Mississippian" periods.

Conclusions from the Factor Analysis

Conclusions from the factor analysis encompass three major areas of inquiry. The first relates to cultural continuity. Do the data support previous working hypotheses that culture change in southwest Missouri was gradual, with new ideas and forms slowly replacing older ones? The second concern of spatial relationships: cultural interaction between populations within the region. The third set of conclusions deal with interactions with populations outside

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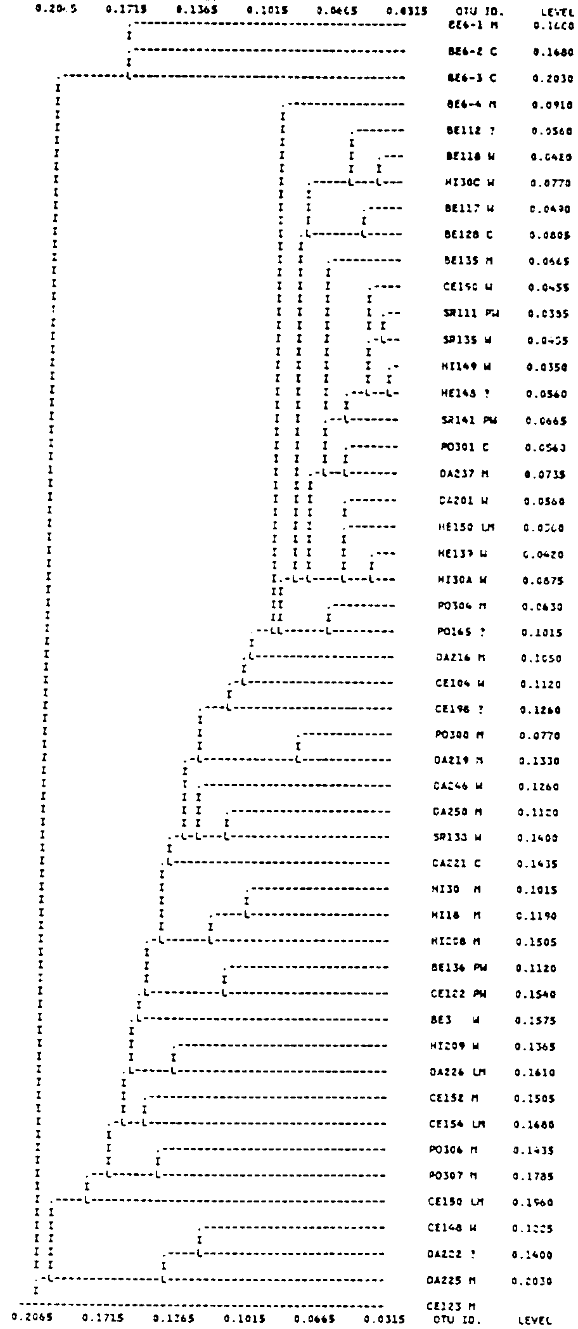


HAS BEEN STORED.

**** ELAPSED TIME IN THIS STEP IS 0.0127 MINUTES. TOTAL ELAPSED SYSTEM TIME IS 0.0546 MINUTES (1, -4)

Figure 15. Cluster analysis of unrotated scores.

southwest Missouri — isolation and trade relationships. Evidence has been amassed from the factor analysis and the small body of absolute dates from the tumuli, that a mortuary complex existed in southwest Missouri which changed very little for over 1000 years. Great time depth is represented: the complex was certainly well-established in the Woodland period, probably by 500 or 600 A.D. Only two tumuli contain evidence of having been built previous to this time, perhaps as early as 900 B.C. Five tumuli appear to have been in use at the time of white contact, no earlier than A.D. 1650. Although more dates are needed, particularly from the Woodland period, it would appear that this mortuary complex in southwest Missouri continuously spanned at least 1000 years.

The factor analysis was useful for differentiating between assemblages of artifacts which are presumably temporally diagnostic, thus enabling classification of tumuli into general periods. However, the seriation of tumuli was based on the assumption that a tumulus dates to the period of its most recent inclusion. Such an assumption, while perfectly valid if each tumulus represents a single episode of construction, masks all other variability in the assemblage at each site. Thus, while there were seven or eight factors describing temporally sensitive artifact associations, there were eight others describing non-temporal dimensions. These dimensions point to the fact that there are trends in artifact inclusion which continue through several time periods. Moreover, a factor analytic model does not account for all variability, unless all roots are extracted. In the present analysis, only the major co-occurrences (78% of the variation) were described. Thus, sporadic, transitional patterns which occur during cultural change, such as retention of older forms and gradual replacement by newer forms, are not extracted.

The eight non-temporal dimensions, as well as the frequency of occurrence of ubiquitous artifact types throughout several time periods, support the continuity hypothesis. There seems to have been a generalized pattern of mortuary inclusion which was retained from time period to time period. Thus, several tumuli in the "Woodland" period contain Afton and Table Rock-Stemmed points, which are hallmarks of the Late Archaic period. Similarly, Rice Side-Notched, Cooper-like Corner-Notched, and Scallorn points, all characteristic of the Woodland pattern in southwest Missouri, are retained and occur in high frequency during periods when Mississippian and White contact artifacts appear. This situation is most obvious in two of the Fairfield tumuli, BE6-2 and BE6-3, where artifacts characteristic of several time periods occur together in the same tumulus. There is certainly no wholesale replacement of cultural inventory during each succeeding period. Rather, a pattern of mortuary inclusion, presumably

indicative of more general adaptive strategies adopted in the Late Archaic period, was retained until the historic period.

Several patterns of spatial distribution of the tumuli have been discerned through the factor analysis. The most interesting of these is the differential patterning which occurs in different time periods. These patterns are illustrated in Figures 16 through 18. In the two "Woodland" periods it seems that the tumuli occur throughout the study area. Few clusters of tumuli occur, and when they do, it is in pairs (i.e., DA246 and DA201, HI30a and HI30c, SR111 and SR141; see Fig. 16). In the two "Mississippian" periods the spatial distribution of tumuli is radically different (see Fig. 17). Once again, areas of burial occur in many parts of the study area. However, the majority of the sites are in the Stockton Reservoir area. Both in this southern region and in other areas where they do occur, they are generally spatially clustered. Moreover, they are clustered on the higher order streams, much unlike many of the earlier tumuli. Additionally, more of these later tumuli are overlooking the confluences of two major streams.

Such spatial patterning, taken at face value, would tend to indicate that during the later prehistoric periods major shifts in settlement pattern were being effected. A plausible explanation for such shifting might be the exigencies created by the adoption of corn horticulture. Such adoption of intensive agriculture would require movement to the broader river valleys and a more sedentary settlement. This change in subsistence might allow larger aggregates of population.

Other patterns in the archeological record, however, lend little support to such an explanation of the far-reaching effects of corn on local populations. First, there are the skeletal data which show that even in areas where corn was present, its use in the diet was probably quite limited (Brock 1980). Second, there is no known environmental factor, such as climatic change, which would confer benefits to those populations in the Ozarks which switched subsistence strategies to intensive horticulture. In fact, the Woodland pattern of hunting and gathering seems ideally suited to an area with narrow stream valleys and soils unsuited to horticulture. Third, and most important, is the fact that there is evidence of occupation throughout the region during this later period, on open sites and in shelters not confined to just the major streams.

Spurious conclusions about "Mississippian" period settlement pattern could easily be drawn from negative evidence of two types: (a) the absence of late tumuli outside

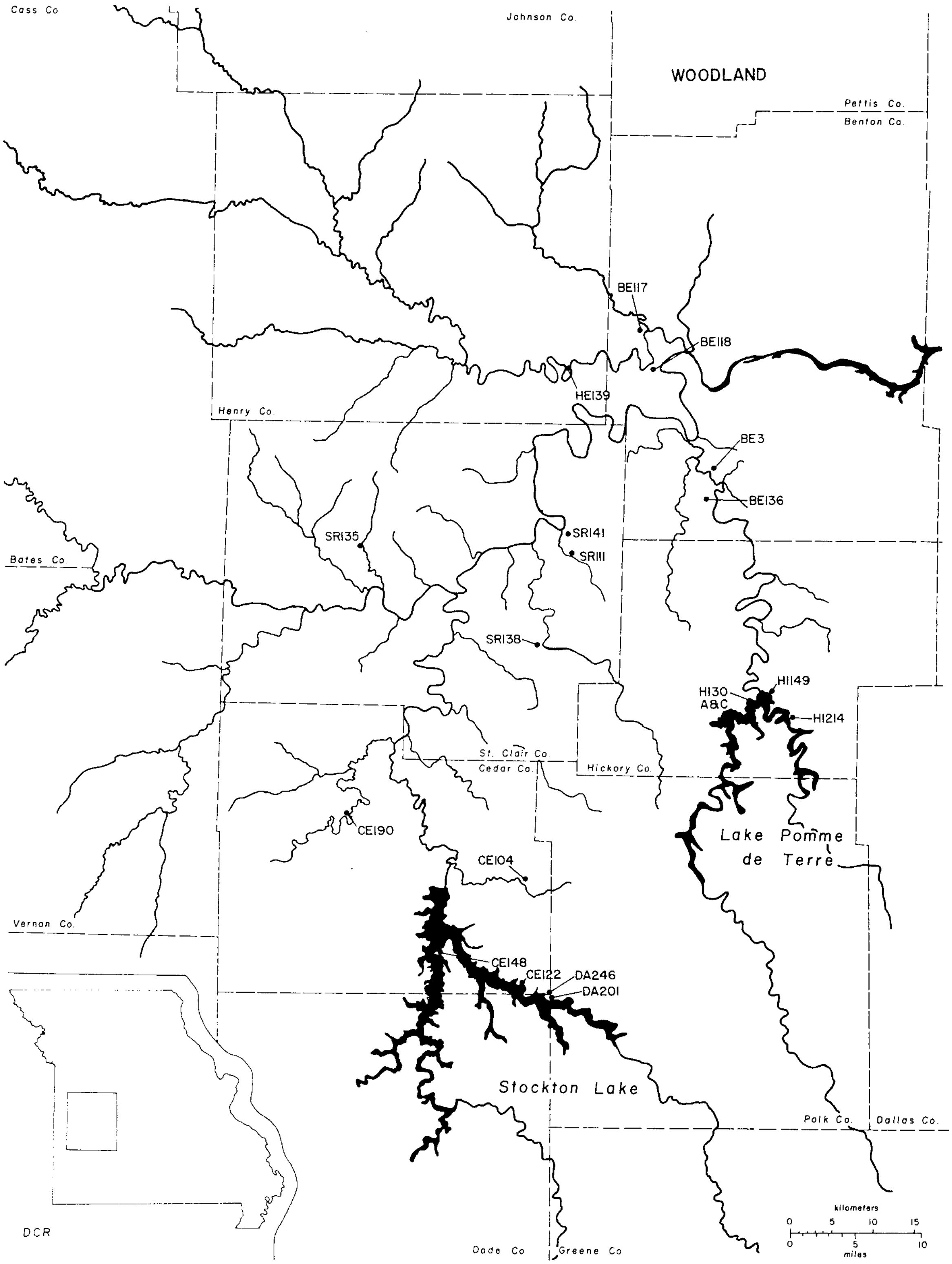


Figure 16. Spatial distribution of "Woodland" tumuli.

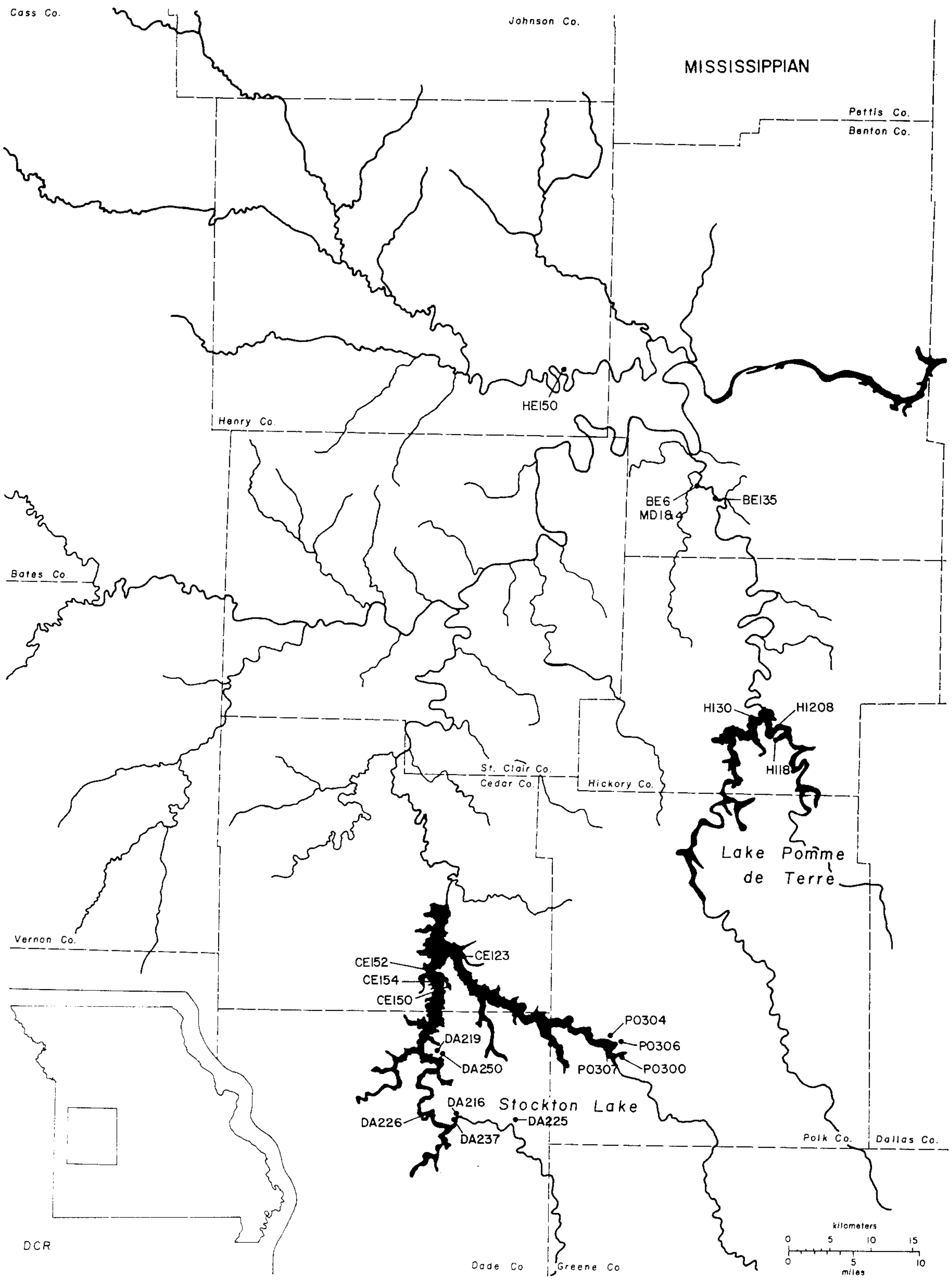


Figure 17. Spatial distribution of "Mississippian" tumuli.

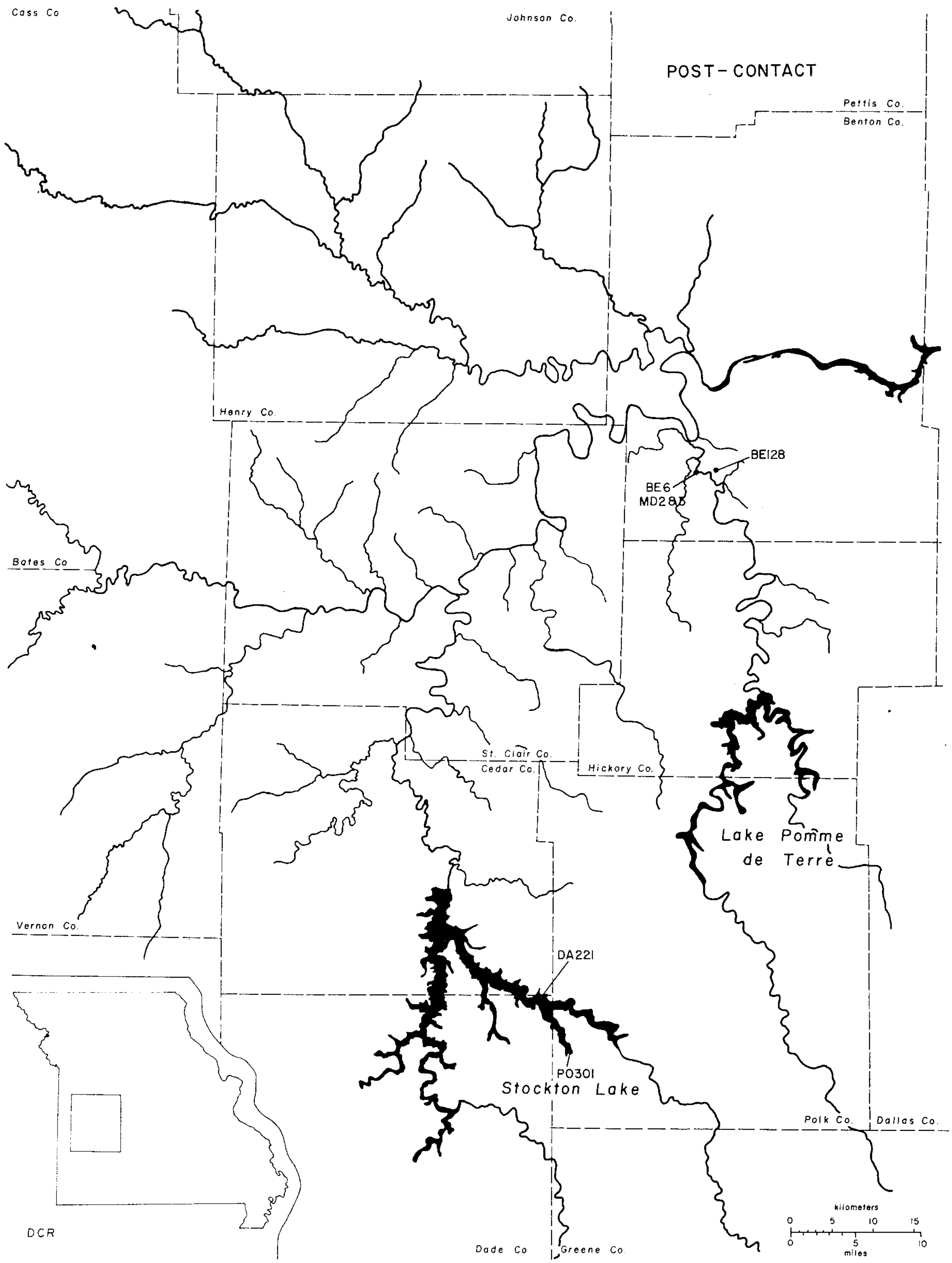


Figure 18. Spatial distribution of "Contact" tumuli.

of three spatial groupings, and (b) the small number of "Mississippian" horizon markers in other site types throughout the area. In both cases the negative evidence is suspect. The area where the "Mississippian" tumuli seems to be under represented is in the Truman Reservoir area. The first archeological surveys in the area were concentrated in the river bottoms. Recording and excavation of tumuli was not emphasized (except in the southwest corner of Benton County) as it was in the Stockton and Pomme de Terre Reservoirs. Further work may negate this negative information.

The other type of negative data may be explained by the physical characteristics of diagnostic "Mississippian" materials: viz., small arrow points and pottery. Only fifteen sites were recorded in the Stage 1 and 2 surveys in Truman Reservoir which had these diagnostic points (Roper 1977). Unfortunately, these artifacts are probably the least likely of all types to appear during a surface survey. From the distribution of these fifteen survey sites, it is obvious that the later occupations were not confined to the areas around clusters of "Mississippian" tumuli.

What, in fact, may be happening, is that some of the tumuli in the sample, from the areas distant from the clusters of "Mississippian" tumuli, may date to a later period than is postulated. The tentative seriation is based on cross-dating of artifacts. That some tumuli did not contain "Mississippian" artifact forms does not prove that they were not built during the "Mississippian" period. In fact, it was shown that many of the later tumuli contained artifact assemblages very similar to the "Woodland" tumuli, but with the addition of new traits. Such patterning only supports the notion that the southwest Missouri populations possessed a pattern of adaptation which changed slowly and was little influenced by outside contact.

The final set of conclusions is concerned with this outside contact – the nature of the relationship with outside populations and its effect on the archeological patterning in southwest Missouri. That there was contact with other populations from surrounding regions is obvious from the artifact assemblages in the tumuli and other site types in southwest Missouri. Some of the more ubiquitous types of projectile points, such as Scallorn and Gary, and bone tools, are wide spread and prevalent elsewhere. The occurrence of such types seems to be indicative of a general pattern of adaptation to a woodland environment. However, the Ozarks populations, as did those in many other regions who are part of the general woodland pattern, possessed certain artifact types which have a character or style all their own. The most notable of these in the Ozarks are the Afton, Rice Side-Notched, variants of the Rice Side-Notched, and Cooper-

like corner-notched points. These types do occur elsewhere, but seldom in the high frequency that they do throughout the Ozarks.

All of the tumuli in the sample contain artifacts characteristic of this regional variant of a woodland adaptation. However, several contain artifacts which must have derived from elsewhere, either in idea or physical manifestation, through contacts with outside populations. Even part of the mortuary program (discussed in the following chapter) may have originated outside the area.

Outside contacts occurred throughout the study area, but were sometimes regionally or temporally restricted. The earliest evidence of contact is in the form of classic "Hopewellian" artifacts. Eight tumuli contain either Snyders points or cut wolf-maxillae. One of these, BE3, contains both, and another, BE6-2, contains a cup-stone or mammiform object. Similar artifacts have been found in areas outside of the Hopewellian centers of Illinois and Ohio. Most notable are those sites in central Missouri (Heldman 1963) and eastern Kansas (Wedel 1943; Eyman 1966; Johnson 1976) which contain late Hopewell artifact types and have been explained by movement along the Missouri River, westward from Illinois during the late Middle Woodland period. It seems that the southwest Missouri populations had a trade relationship with these Hopewellian influenced populations from central Missouri, via the Osage River, and/or populations in Kansas, perhaps via the South Grand or Osage rivers. It is interesting to note that those tumuli with Hopewellian artifacts are primarily in the northern part of the study area.

The effects of such Hopewellian contact are difficult to assess. Although less diagnostic than cut wolf-maxillae and Snyders points, there is a group of corner-notched dart points, classified in this study as Cooper-like points, which may indicate contact with Hopewellian influenced groups in other regions. Points similar to these are found in Kansas City Hopewell sites (Shippee 1967) and Cuesta sites (Marshall 1972) in eastern Kansas. They are also found in great quantity at the Cooper site in northeastern Oklahoma, which is interpreted as a site-unit intrusion by a Hopewellian group (Purrington 1971). Cooper-like forms are common in several of the tumuli in the northern part of the study area, during the "Woodland" period. The style <u>may</u> be attributable to outside contact, as could the Rice Side-Notched forms (see Appendix A: Cooper-like corner-notched and Rice Side-Notched for further discussion). However, such an argument, based on a conjectural evolution of point styles, has little validity. Also, given that the more diagnostic, or "classic," Hopewell artifacts occur in small numbers, and always in assemblages with indigenous artifact

types, it is certain that their presence cannot be explained by population replacement. Rather, it seems that contact with these Hopewellian influenced groups resulted in exchange of a few artifacts and of ideas which potentially had an effect on subsequent artifact manufacture and mortuary patterns.

The temporal placement of such contact is also difficult to determine. The two radiocarbon dates on BE3 (a tumulus with Snyders points and a cut wolf-maxilla) of 225 B.C. and A.D. 95 seem too early, given the presence of two Reed arrowpoints in the tumulus. A date of A.D. 500 or 600 would be more appropriate if the postulated relationship with other Woodland groups, and Bell's (1958) assessment of the appearance of Reed points, are correct. Three other tumuli, BE136, SR111, and CE122, may slightly precede BE3 in time, but not by much more than 100 years or so. Other tumuli with Hopewellian artifacts may date to around A.D. 700 or later, based on Bell's (1958) temporal placement of Scallorn arrowpoints. Two exceptions to this pattern are DA250 and BE6-2. Presence of Snyder points in these tumuli which date to "Mississippian" and "Contact" periods, respectively, support the notion of cultural continuity, or perhaps curation of certain pieces for extended periods of time.

The next period of contact which can be identified from artifacts in the southwest Missouri tumuli is the "Mississippian." Throughout the eastern United States, after approximately A.D. 900, particularly on the major rivers, there were cultural manifestations characterized by large aggregates of population, sedentism, corn horticulture, large ceremonial centers and concomitant complexity in social organization. The presence of several horizon markers of the period make it possible to state that the populations in the Ozarks were in contact with these cultures. These include small, multiple-notched, triangular arrow points, diagnostic vessel forms and temper, and possibly maize.

Generally, few of the arrow points which are diagnostic of this period are also identifiable to a specific region of origin. Types such as Huffaker and Washita, which are prevalent in and may have developed in the Caddoan region, are sometimes found in areas farther east, along the Mississippi River. An organized trade network was in existence between regional centers such as Cahokia and Spiro. Thus, while the occurrence of Huffaker and Washita points in southwest Missouri may indicate contacts with populations to the west, such an origin is only likely, not certain. Such a pattern of contact seems to have developed in an earlier period. The co-occurrence of Reed points and mollusk beads in the tumuli point to contacts with Plains groups, perhaps as early as A.D. 500.

Some artifacts are more certainly derived from contacts with Caddoan populations southwest of the study area. Haskell and Keota points, and a Sprio Engraved water bottle (DA250) indicate that the builders of at least five tumuli had such contact. It is interesting to note that these tumuli are all in the Stockton area, closest to the Caddoan region. It has been suggested also (Chapman, personal communication) that the maize in the southwest Missouri tumuli had a similar origin.

While most of the tumuli in the study area with evidence of "Mississippian" contact are in the Stockton Reservoir area, such influence is not confined to that area. The major difference between the Truman Reservoir area and the Stockton area, in terms of outside contact, is the absence of corn in the north. Perhaps this may be explained by differential preservation. Although the two areas are not appreciably different in terms of soil acidity (Allgood and Persinger 1979; Grogger and Persinger 1976), or rainfall (U.S. Department of Commerce 1965), both bone and pottery are better preserved in the Stockton area, and the same may hold true for vegetal remains.

On the basis of the distribution and co-occurrence of artifact forms it would seem that contact with "Mississippianized" populations had little effect on the populations in southwest Missouri. The tumuli with these Mississippian artifacts are confined to the major rivers in the study area, implying that the contact did not penetrate the region. Depending upon the actual trade routes between centers such as Cahokia and Spiro, we might expect some contact with populations encountered along the way. Moreover, in every case, these "Mississippian" artifacts occur in the same tumuli as do the more characteristically indigenous "Woodland" artifact forms. This would indicate that there was retention of former cultural patterns, even in the face of new ideas and forms. Such retention of patterns is epitomized in the acceptance of maize horticulture, presumably without the development of a dependence on it, to the exclusion of other subsistence activities (Brock 1980).

There are two other kinds of evidence which show that the southwest Missouri populations were in contact with other regions. The first of these is identified by Factor 7, with the co-occurrence of marine shell beads and conch pendants. The presence of these implies contact, either directly or indirectly, with the Gulf Coast. These occur in all periods, throughout the study area.

The second form of evidence of contact is the presence of exotic cherts in the tumulus assemblages. Appendix C includes data gathered on the types of chert used for artifact

manufacture. Well over half of the tumuli contain at least one piece of chert which is not represented in the study area. Moreover, none of these "exotic" pieces could be matched to a comparative collection made from northeastern Oklahoma, eastern Kansas, central Missouri, and the St. Louis, Missouri areas.

The procurement of either raw materials or finished artifacts from non-local materials was widespread through both the spatial and temporal dimensions. These distributions of exotic chert occurrence are presented in Tables 11 and 12. Use of exotic chert was most prevalent during the "Woodland" and "Mississippian" periods. Perhaps it was a measure of the amount of contact with outside populations during these periods. Spatially, there seems to be no significant difference in the percentage of exotic pieces per area compared to number of pieces identified (10% or 11%). It is interesting to note that only in a few cases were the tools manufactured from the exotic chert stylistically different from other tools in the assemblages.

The analysis of artifact co-occurrences and forms, as well as the chert data, indicates that contact with outside populations was a pattern developed at least as early as the pattern of tumulus burial. This pattern continued up until the period of white contact. It is proposed that such contact was minimal in terms of the effects it had on previous cultural adaptations in the area. This trade relationship brought about the exchange of material goods and probably ideas. The origin of this contact is uncertain, but most likely involved populations to the north, during the Woodland period, and to the south and west during the Mississippian period. Other patterns of trade, for such items as shell and chert, seem to have been continuous for the entire span of the burial complex.

TABLE 11

Exotic Chert Distribution - Temporal Dimension

Period	# Pieces	# Exotics	Percent
Late Archaic	30	2	6.7
Pre-arrow Woodland	88	8	9.1
Woodland	226	32	14.2
Mississippian	206	25	12.1
Late Mississippian	86	9	10.5
Contact	361	30	8.3

TABLE 12

Exotic Chert Distribution - Spatial Dimension

	Truman	Pomme de Terre	Stockton
Total # Pieces	562	53	416
# Exotic	62	6	40
Percent Exotic	11	11	10
Total # Tumuli	16	6	23
# with Exotics	9	5	15
Percent with Exotics	56	83	65

CHAPTER 6

TUMULUS FORM AND STRUCTURE

An analysis of the form and structure of the tumuli should shed more light on the relationships among the populations in southwest Missouri, as well as on contacts with populations in other regions. This chapter will examine patterns in the form and structure as they relate to temporal and spatial patterns discerned in the factor analysis. It is postulated that, similar to the artifact assemblages, there will be gradual change through time and only slight differences across space. Finally, the form and structure will be compared to that of tumuli in other regions, in an attempt to identify the types of contact occurring between cultural regions.

Form

All of the tumuli are circular to subcircular in outline, are dome-shaped, and consist of rock or of rock-and-earth fill. They range in diameter from 13 to 40 feet and in height from six inches to three feet (Table 13).

Although all of the tumuli are filled, at least partially, with stone, some also contain earth. It was this difference that led Wood (1961, 1967) to define two concepts or traditions of construction, viz., cairns and mounds.

> "Cairns consist of tumuli which are composed almost entirely of stone. The original intent, at least, was that the monument consist solely of stone, but after its completion wind-blown soil and humus accumulated between the stones and settled to its base. Mounds are tumuli containing nearly equal quantities of stone and earth, from the surface of which protrude numerous large and small stones. In practice, however, differentiating between the two types of structures offers a real challenge; for there are many intermediate examples" (Wood 1967: 109).

Following the determinations of the excavators of each tumulus, thirty-six structures were classed as mounds and eighteen as cairns (Table 13).

Wood (1961: 117) initially postulated that all tumuli were originally cairns, and that the amount of earth in a tumulus was attributable to wind blown soils and humus; older cairns thus become mounds. Further observation led

TABLE 13

Tumulus Form and Structure

Site	Mound/ Cairn	Diameter (in feet)	Height (feet)	Disturbance+	Structure Type*	Comments
BE6-1	M	28.5	1.5	1	0	
BE6-2	C	33.0	2.0	1	0	
BE6-3	C	39.0	2.0	1	0	
BE6-4	M	20.0	1.0	1	0	
BE112	C	19.0	1.0	1	0	
BE117	M	20.0	1.0	0	0	
BE3	M	23.0	1.5	1	2	Ring of stones in S.E. quadrant around part of the burials
BE128	M	15.0	1.0	1	0	
BE118	M	18.5	1.0	1	0	
BE135	M	18.5	1.0	1	0	
BE136	M	19.0	1.0	0	2	Large ring of large rocks containing burials
CE104	C	18.0	1.0	0	1	Central pit with ash and part of burials
CE122	M	18.0	1.0	0	2	Large stone ring containing burials
CE123	C	18.0	2.5	0	0	
CE190	M	20.0	1.5	2	0	
CE198	M	17.0	0.8	0	2	Ring of large rocks containing burials
DA201	M	19.0	2.0	1	0	
HE139	M	15.5	0.7	0	0	
HI30	C	35.0	3.0	2	2	Square stone chamber including all burials and an oval stone ring
HI30a	M	40.0	1.5	2	0	
HI30c	M	22.5	1.0	2	0	
HI149	M	14.0	1.0	1	1	Shallow central pit
HI209	M	14.0	0.5	?	1	Rectangular pit containing burials
SR111	M	18.0	1.0	2	0	
SR135	C	18.0	2.0	?	?	
SR141	M	13.0	1.0	2	0	
CE148	M	19.0	1.5	0	2	Stone ring containing most burials
CE150	M	21.0	1.5	0	0	
CE152	M	21.5	1.5	0	0	

TABLE 13: Continued

Tumulus Form and Structure

Site	Mound/ Cairn	Diameter (in feet)	Height (feet)	Disturbance+	Structure Type*	Comments
CE154	M	17.0	0.5	0	0	Small rock filled, 2½ ft. deep pit with no burials
DA222	M	16.5	1.0	0	0	
DA225	M	21.0	1.0	1	2	Stone ring with some burials inside, some outside
DA226	M	23.0	1.0	1	0	
DA246	M	20.0	3.0	2	0	
PO306	M	20.0	1.0	?	0	
PO300	M	23.0	1.5	1	0	
PO301	C	23.5	1.5	2	0	
PO307	M	20.0	1.5	2	1	Two sub-floor pits, one with burial, one with artifacts and corn
HI18	C	25.0	2.0	2	0	
HI208	C	37.0	1.0	0	2	Rectangular ring of rocks containing burials
PO304	C	20.0	1.5	2	0	
DA250	M	19.0	1.0	2	0	Small stone semi-ring around one burial
DA216	C	19.0	2.0	1	0	
DA237	C	15.5	1	0		
DA219	M	21.0	1.5	1	0	Hearth with charcoal and ash, but no burials
BE137	C	18.0	1.0	0	1	Central pit containing burials
HE147	C	18.0	1.0	0	0	
PO165	C	25.0	3.0	2	0	
DA221	M	19.0	1.5	1	1	Rectangular pit containing burial
SR138	M	25.0	1.5	1	0	
HE150	C	25.0	1.5	1	0	
HE148	C	18.0	1.0	1	0	
HI135	M	26.5	1.0	2	0	
PO305	M	28.5	1.3	1	1	Sub-rectangular pit, slab-lined floor, containing burial

+0 = none
1 = some
2 = extensive

*0 = none
1 = pit
2 = ring

him (1967: 109) to conclude that the original explanation did not account for the weathered, gravel-sized stones, or the large amounts of human bone in the upper fill of the mounds.

Two tests are presented here which relate tumulus form to the temporal and spatial dimensions of the burial complex. Chi-square analysis is used to test whether patterning in tumulus form is related to cultural relationships, with tumuli of either a given period or geographic area more similar to one another than to those of other periods or areas.

The first chi-square tests the relationship between form and space. Tumuli were categorized into three spatial units (Truman, Stockton, and Pomme de Terre Reservoir areas), and the frequencies of mounds and cairns tabulated (Table 14). The resultant chi-square value of 0.72, with two degrees of freedom, can be expected to occur by change between 75% (Tabled value = .575) and 50% (Tabled value = 1.386) of the time.

The second chi-square tests the relationship between form and time period. Using the tentative seriation derived from the factor analysis, the tumuli were categorized into four groups (Archaic, Woodland, Mississippian, and Contact). The number of mounds and cairns occurring in each period were then tabulated (Table 15). The resultant chi-square value of 9.65, with three degrees of freedom can be expected to occur by chance between 2.5% (Tabled value = 9.348) and 1.0% (Tabled value = 11.345) of the time.

The results of the two tests point to a highly significant relationship between tumulus form and the time period in which it was built, but show no significant trends in the spatial distribution of mounds and cairns. While there is a significant trend through time, with an increased percentage of cairns, it is clear (Table 15) that neither tumulus form occurred to the exclusion of the other during the last three periods. Such a pattern supports the notion that culture change in the Ozarks was gradual. The spatial analysis suggests that such changes occurred throughout the region and that there were no areas in which culture prescribed the tumulus form.

Structure

Several of the tumuli contained structural features (Table 13). These were usually one of two general forms: accumulations of larger rocks and pits. Seven tumuli contained large rings of stone which often contained most of the skeletal materials. Of these seven, the five mounds

TABLE 14

Chi-Square Analysis of Form X Space

Area	Mound	Cairn
Stockton	18	7
Truman	12	8
Pomme de Terre	6	3

Chi-Square = 0.72 df = 2 $.75 > p > .50$

TABLE 15

Chi-Square Analysis of Form X Time

Time	Mound	Cairn
Archaic	2	0
Woodland	18	1
Mississippian	13	8
Contact	2	3

Chi-Square = 9.65 df = 3 $.01 < p < .025$

had circular or oval rings of rock and the two cairns had rectangular rings. Smaller, more isolated rings of stone were found in two other mounds, as well as one within the rectangular structure of HI30, described above.

The other general form of feature, pits, were found in eight other tumuli. Three mounds had rectangular pits which housed the burials. Four other tumuli had shallow pits dug into the central part of the tumulus floor. One of these tumuli, PO307, as well as CE154, had a pit containing only rock and artifacts with no skeletal remains.

The thirty-five other tumuli contained no structural features. In these, the original ground surface was not altered in the form of pits. However, bedrock slabs were sometimes rearranged to create flat surfaces, with burials occasionally placed in crevices in the bedrock. The fill in these thirty-five tumuli was generally undifferentiated and unstructured.

Chi-square tests were run on the structure data. For each test, the same groupings of tumuli were used as in the previous analyses. Contingency tables were set up (Tables 16 and 17) on the basis of: 0 = no internal structure; 1 = sub-floor pits; and 2 = stone rings or chambers.

Results were similar in both the temporal and spatial analyses. When structure was compared across the temporal dimension, the resultant chi-square was 6.65 (see Table 16). With 6 degrees of freedom, these results could occur by chance between 50% and 25% of the time. When structure was compared across the spatial dimension, the chi-square was 2.26, with 4 degrees of freedom; a value which would occur by chance between 75% and 50% of the time (Table 17).

From these results it is clear that there is no strong spatial pattern to the occurrence of structural forms in southwest Missouri. All structures seem to occur randomly throughout the area, as do tumulus forms. Such randomness in the spatial dimension argues for cultural contact among the tumulus builders from all regions of the study area.

Similarly, there is a pattern of random variation in structure through time. This randomness does not compare favorably with the pattern of tumulus form, as there is a clear trend toward more cairns in the later periods. To assess the relationship between structure and form, a fifth chi-square was performed (Table 18). The resultant chi-square value of 1.77, with two degrees of freedom, can be expected to occur by chance between 50% and 25% of the time.

The random relationship, here, seems to indicate that the cultural forces which caused a shift in the number of

TABLE 16

Chi-Square Analysis of Structure X Time

Time	Structure		
	None	Pit	Ring
Archaic	0	1	1
Woodland	11	3	4
Mississippian	16	2	3
Contact	4	1	0

Chi-Square = 6.65 df = 6 $.25 < p < .50$

TABLE 17

Chi-Square Analysis of Structure X Space

Area	Structure		
	None	Pit	Ring
Stockton	16	4	5
Truman	16	1	2
Pomme de Terre	5	2	2

Chi-Square = 2.26 df = 4 $.50 < p < .75$

TABLE 18

Chi-Square Analysis of Form X Structure

Form	Structure		
	None	Pit	Ring
Mound	24	5	7
Cairn	13	2	2

Chi-Square = 1.77 df = 2 $.25 < p < .50$

cairns being built, did not operate in a similar manner on the internal structuring of the same tumuli. A key to this difference may be found in an examination of the possible origin of these structural and formal traits. The following section will be a brief comparison of mortuary complexes in surrounding areas to those in the study area. Propositions concerning the influence that these may have had on the southwest Missouri populations and their mortuary patterns are then offered.

Mortuary Complexes in Other Regions

The dominant mode of burial in the eastern United States, beginning in the Woodland period, seems to have been in tumuli. Perhaps the epitome of such a complex is the Hopewell ceremonial earthworks centered in Ohio. A second major center, and one which was in contact with the Ohio center (Struever 1965), was in Illinois. The complex in Illinois is less elaborate than the Ohio complex. In Illinois burial sites consist of small groups of relatively small mounds, with few interments. Mound features consist primarily of sub-floor pits and log tombs and lack the diversity of burial preparations, stylistic artifacts, and raw materials, found in the Ohio mounds. Such differences have been attributed to contrasting levels of social integration, direction by a chiefdom in Ohio, and by a more loosely organized lineage system in Illinois.

The relationship which holds between the Ohio and Illinois centers, in terms of elaboration of earthworks and level of social organization, seems to be similar in several areas outside these Hopewellian centers. There is much evidence that groups along many of the major river drainages participated in the trade system which has been named "Hopewell Interaction Sphere" (Struever and Houart 1972). This system, which facilitated the exchange of raw materials from distant regions, also allowed exchange of artifact styles and, presumably, of ideas. It was a network which left traces of cultural traits which, if taken alone, seem to indicate a wide geographic distribution of similar cultural adaptations. However, in that those traits characteristic of Hopewell were the result of a sub-system of culture, these traits seem to be more of a veneer which masks more basic adaptational differences that existed between the groups participating in the trade network.

One region where there is evidence of contact with the Hopewellian groups from the major centers is of most interest to the present study: areas along the Missouri River and its tributaries. A number of cultural complexes from eastern Missouri, up the Missouri River as far north as North Dakota were influenced to some degree by the Hopewellian

populations. This is evidenced by ceramics bearing affinities to the Hopewell series of Illinois, modified animal maxillae, shell artifacts, and stone tools of styles similar to those in Illinois.

Many of these complexes also have burial tumuli associated with them, a trait which appeared concurrently with other Hopewellian-like goods. Based on the timing of the advent of mound construction, as well as on structural and formal similarities, many researchers have suggested that such burial complexes developed as the direct result of Hopewellian contact (e.g., Neuman 1975; Eyman 1966; Wedel 1943). A brief examination of burial complexes along the Missouri River and its tributaries will show the changes in the formal qualities of the Hopewellian burial complex as it was accepted in other regions. The similarities in structure, form, and inclusions of the southwest Missouri tumuli to those along the Missouri River suggest a similar explanation for the advent of mound building in the study area.

In east-central Missouri, along the Missouri River, is a cultural complex defined (Chapman 1948) as the Boone Focus. Denny (1964), in a re-evaluation of this complex, has defined two phases. Burial mounds are typical of both phases. Phase One includes mounds with stone chambers, few grave goods (predominately pottery vessels), and several different burial types. Hopewellian affiliation has been suggested. Phase Two mounds are generally earth-fill with some burial pits. Occasionally rock piles (cairns) are present. There are several different burial types and Mississippian period grave goods.

Further west along the Missouri River in the Kansas City area is the Kansas City Hopewell manifestation and its associated burial complex. The tumuli there are of two varieties: earthen mounds and stone vault mounds. Wedel (1943) has described the stone vaults and compared them to the chambered mounds to the east (along the Missouri and Mississippi rivers). Those near Kansas City were extremely well built of roughly coursed stone, with rectangular chambers, well squared internal corners, and south facing entrances. Those to the east were not as well built and did not have entrances. The western vaults had fewer artifacts and primarily cremated bodies, as opposed to the frequent flesh burials in the east. Based on the Hopewell pottery types and the proximity of the vaults to sites like Renner (with evidence of Hopewellian influenced occupation), Wedel (1943: 185) suggests that this area may be the climax of a trait complex emanating from the east. This complex may have derived from the earlier slab-lined cists or may be a variation of Hopewellian log-tombs.

Farther north along the Missouri River, in eastern Nebraska, there are tumuli which presumably date to the Woodland period (Hill and Cooper 1939). These are loess mounds which contain scattered burials, some of which have been burned. Mound burial was not the only mode of interment in this area, for there are village burials (Hill and Cooper 1939) and large ossuaries such as the Woodruff Ossuary (Kivett 1953), which contained both primary and secondary burials. The northernmost extent of the burial tumuli along the Missouri River are those in South Dakota and extreme southern North Dakota. Some of them are identified as the burial component of the Sonota complex (Newman 1975). They are low, domed earthen structures, ranging from fifty-five to 100 feet in diameter and often occur in clusters. Burials were almost exclusively secondary, often interred in sub-floor pits, with some evidence of log tombs. The relationship between these tumuli and Hopewellian mounds is suggested by pottery, stone tools, and shell, as well as structural features.

A number of other burial complexes similar to these are found along many of the tributaries of the Missouri River. Only in one of these complexes has much archeological excavation been done. In east-central Kansas, west of Lawrence, is the Schultz Focus (Eyman 1966), characterized by burial tumuli. The tumuli are mostly on the Republican River, a tributary of the Kansas River, which, in turn, empties into the Missouri River. Three varieties of structures are represented. Variety 1 mounds, shown inconclusively to be the oldest, contain masonry chambers. Varieties 2 and 3 are earth-fill mounds with sub-floor basins; Variety 2 has individual pits within the basin. All burial types are represented, including some cremations. Skeletal parts were often scattered. The most abundant artifacts were shell and bone beads.

Two other groups of tumuli are in Missouri along tributaries of the Missouri River. They are unnamed due to the fact that little archeological work has been done with them. The first group is on the Gasconade River and its tributaries (McMillan 1965b). Seven of the thirty-seven tumuli, located by Fowke (1910), were excavated. All were rock cairns and overlooked streams. Mostly secondary or scattered burials were present, as well as some cremations. There is some evidence that there was internal structuring in some; what type is unclear. The artifact assemblages in the cairns are also unknown.

The second group of tumuli is on the Lower Osage River, closer to the present study area. Both earth mounds and rock cairns were located (Klippel 1965) but none are excavated. All were on elevated areas overlooking streams. The distinction

between mounds and cairns was sometimes difficult to make. In this case, the form of the tumulus may have depended upon access to materials. The mounds were restricted to the lower reaches of the river where earth was available. Cairns were more numerous in the upland wooded areas nearer what is now the Lake of the Ozarks, an area where rock is more than abundant.

Several patterns emerge in this discussion of burial complexes west of Illinois. The tumuli on the Missouri River are comparable in size, form, and number of interments, to those in Illinois. All include some artifacts which show affinities to Illinois Hopewell. Also, the advent of such a pattern of mound building is either during or slightly after the Middle Woodland period in Illinois. The most efficacious explanation of such affinities, and one proposed by all of the researchers in these areas, is that this mortuary pattern emerged as the result of contacts with Hopewellian peoples.

One of the major differences between the tumuli of the two areas is in the number of secondary burials in the Missouri River mounds. Neuman (1975) has offered a plausible explanation for the difference. The dominant form of burial in this area, before the Woodland period, may have been scaffolding, or scaffolding and burning. A change in the mortuary program induced by contact may not have entailed change in all aspects of the former burial program. Bodies processed in the older, typical way may, then, have been reburied in the newer fashion.

Although many of the similarities between mounds on the Missouri River and those in Illinois also pertain to tumuli on Missouri River tributaries, there are two major differences. Although internal structure is often similar, with burial pits and chambers, the use of rock as fill dominates on the Gasconade and Lower Osage rivers and in the study area. This is most likely related to physiographic differences in the type of fill that was most readily available. The fact that loess was not present in the smaller river drainages to the south of the Missouri River limits the amount of earth on the bluff tops. For this reason, it may also have been easier to erect a rock chamber above the surface to enclose burials, than it would have been to dig "classic" Hopewellian burial pits into the rocky uplands.

The second difference between the Schultz Focus, Gasconade, and Lower Osage tumuli and the others is in terms of tumulus size and numbers of burials; i.e., the tumuli are smaller and contain fewer burials in the Schultz, Gasconade, and Lower Osage. This smaller scale is probably explained by the size of the population aggregates possible in smaller drainages.

Conclusions

The proposition is advanced here that the advent of tumulus construction as part of the mortuary program in southwest Missouri was the result of contact with Hopewellian or Hopewellian-influenced populations from the north. Much of the internal structuring in the southwest Missouri tumuli is similar to (although less refined) than that in tumuli where Hopewellian contact has occurred. Furthermore, many of the artifacts show affinities to Hopewell artifacts. A continuous distribution of tumuli along the Missouri River and up the Osage River would also argue for such contact.

One disconcerting fact might potentially weaken such an argument. Artifacts from two tumuli, HI135 and PO304, typologically date to the Late Archaic period. A thermoluminescense date, on an Afton point (2864 BP $\pm$ 427), supports this temporal placement. However, two radiocarbon dates of the burial itself, from HI135 (835 BP $\pm$ 105 and 520 BP $\pm$ 135), would indicate that this tumulus was built during the Late Mississippian period. Such a possibility is not unreasonable to consider. First of all, the HI135 tumulus was built for a single individual, as was PO305 (Brock personal communication). The only other tumuli definitely containing only one individual date in the Mississippian and White contact period. If these tumuli were built at a date later than the Late Archaic, the presence of typologically early (and radiometrically early) artifacts could be explained by prehistoric curation practices.

Further dating is necessary to support or reject the postulated origins of the idea of tumulus building in southwest Missouri. However, it seems clear that Hopewellian contact played a role in shaping the form of mortuary practices in southwest Missouri. Even if the date of the construction of two tumuli during the Late Archaic period is validated, it seems unreasonable to assume that these were the basis for a mortuary complex which occurred 1500 years later.

That the tumuli are different in some ways from Hopewell mounds may be explained by physiographic differences (use of rock as fill), adaptational differences (smaller aggregates of population), and retention of part of the former mortuary program (secondary burials). All of these patterns are seen in other areas which have been influenced by Hopewellian populations.

Patterns of tumulus form and structure within the study area seem to indicate that, once established, the burial pattern spread throughout the region and remained fairly stable through time. The only significant difference between

earlier and later periods is the increase in the number of cairns, relative to mounds. Such a pattern may be explained vis à vis physiographic conditions and the adoption of a new idea. Given the prevalence of rocks in the majority of locations where tumuli were constructed, perhaps the most expeditious procedure would have been to heap up rocks. However, depending upon how firmly the morticians wanted to conform to the Hopewellian form of earth-fill mounds, they may have expended the extra energy necessary for collecting and transporting earth. As time went on, and the Hopewellian form faded, a change to the more energy efficient cairn may have occurred.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The preceding factor, cluster, and chert analyses of artifact assemblages, as well as analyses of tumulus form and structure, have allowed the recognition of archeological patterning in the southwest Missouri mortuary program. Describing the temporal and spatial variability in the sample has enabled us to better understand the relationships between cultural units within the region. Similarly, relationships which existed between these populations and those in other regions have been identified. Several propositions have been offered concerning the initial questions of cultural isolation and conservatism. By way of summary, the following conclusions are presented, in answer to the questions posed earlier.

1. The burial program in southwest Missouri appears to be the result of intermingling of ideas from different regions. The burial program, which seems to have developed throughout the region sometime in the Woodland period, perhaps around A.D. 600, is probably the direct result of contacts with Hopewell influenced populations to the north. The idea of erecting monuments over the dead was probably an adopted trait. However, aside from the tumulus form and some aspects of the structure, all other aspects of the program may be attributed to the local indigenous populations. Most of the burial accoutrements are typical of non-burial assemblages within the region. The practices of intering numerous artifacts with the dead and secondary burials of several forms are different from Hopewell practices. It is proposed that the idea of mound building was grafted onto former patterns of disposal (perhaps scaffolding and burning) which were determined more by seasonality of death than by a cultural norm of proper burial form.

2. Isolation of the populations in southwest Missouri from cultural developments in other regions was certainly not complete. The cultural manifestations found in the area are not confined to the region. It has been shown that many other regions throughout the Midwest adopted similar modes of burial when influenced by outside groups. Additionally, several of the artifact forms in the tumuli were adopted from other regions at several different time periods. Some of these are widespread tool types and forms which occur throughout wooded environments similar to the Ozarks. Also, about ten per cent of the artifacts in the tumuli were manufactured from non-local cherts, indicating either travel into other regions, visitors to the study area, or trade.

3. It is postulated that while the populations in southwest Missouri were in contact with others outside the region, this relationship had little effect on the lifeways of those people. Few of the artifacts in the tumuli are unlike those in open site and shelter assemblages throughout the Ozarks. Those that are exotic to the area are found predominately in a mortuary context. This would be the expected pattern if these artifacts were not wholly incorporated into the adaptation system, but were held in elevated status due to their scarcity. A similar pattern can be seen in artifacts indigenous to the area, and occurring frequently in functional contexts; when they occur in a mortuary context, many show evidence of extremely careful workmanship.

Three other patterns support the proposition that the occurrence of exotic goods represents a trade relationship. First, while the indigenous cultural assemblages show a high degree of continuity through time and across the study area, the pattern of exotic goods does not. While a few exotics (such as marine shell) are found during all periods throughout the area, there seems to be differential patterning of other non-local goods. During the Woodland period, exotics are found primarily in the northern part of the region. This pattern of contact seems to shift to the Plains and to an area to the southwest in later periods. Such a shift would imply that organized interaction with outside groups was not continuous throughout the duration of the mortuary complex. Additionally, during the "Mississippian" period, the trade items seem to be confined to sites along major streams. The items and ideas adopted by the indigenous populations seem to be peripheral to the mainstream of life. Further evidence of the limited effect of contact is the continued occurrence of artifacts typical of earlier periods, with items typical of outside "Mississippianization."

4. There seems to be a fairly high degree of homogeneity among the assemblages, forms, and structures represented in the tumuli of the study area. No regional differences were apparent in the form or structure of the tumuli, implying that contact among the populations led to a common form of burial program. Some differences between areas can be seen in the artifact assemblages. The tumuli in the Stockton region display the most sub-regional clustering in respect to artifact inclusions. This sub-regional variation may be partially explained by differential preservation of bone and vegetal remains. Also, much of the variability in the artifact assemblages of the total sample may be due to the effects of outside contact.

In spite of some regional differences, almost all of the tumuli share, to some extent, certain artifact forms. It appears, then, that the builders of all of the tumuli were

part of a basic cultural system, adapted to the Ozarks environment, and sharing tool forms and ideas. However, within this system, there was regional variation. Such a pattern would be expected in an area where small groups and mobility were at a premium. While groups were probably in contact with one another, allowing transfer of goods, people, and ideas, such contact may have been fairly random. Through this process of contact and exchange, a type of cultural homogeneity would be effected. However, it is likely that groups closest to one another, in more frequent contact, would be most similar.

5. It is suggested that the populations in southwest Missouri possessed a system of adaptation which persisted from the Late Archaic period until a period of Euro-American contact. This system developed in response to environmental conditions in the post-Hypsithermal. During this 2500 year period some cultural change did occur; tool forms and styles were gradually replaced by others. However, as indicated by the artifact assemblages and tumulus form, this change was gradual.

This actual rate of change is, as yet, unmeasurable. However, what is important, is to understand the change in the Ozarks in relation to cultural developments in other areas of eastern United States. The notion that Ozarks populations were isolated and, therefore, conservative and backward is untenable. That the patterns in the Ozarks do not reflect the Hopewellian and Mississippian developments in other areas is obvious. The contact that the southwest Missouri populations had with other populations clearly did not result in changes in the basic adaptation systems as occurred elsewhere. Elaborate artifacts, intensive horticulture or collection strategies, and stratification of social systems simply did not occur in this region.

The reasons for such a pattern seem just as obvious as is the evidence for the pattern itself. Cultural developments of the sort the southwest Missourians did not participate in, took place in a few specific biomes where exploitation of selected, high-yielding resources was possible. In the Middle Woodland period these resources were probably nuts, seeds, deer, waterfowl, and fish (Struever 1968). During the Mississippian period, maize horticulture seems to have been a dominant resource. Given the environmental limitations in the Ozarks, such intensification – and concomitant population aggregation and growth – was probably undesirable, if not impossible (see also Roper 1979). Although there is a diverse resource base in southwest Missouri, quantities of each resource were limited (Roper 1978). Moreover, these resources occur in a mosaic pattern, unlike the banded pattern found along major river valleys such as the Illinois, Mississippi,

and Missouri. Also, the bottomlands are much narrower, and soils are poorly drained; all these conditions are unfavorable to a subsistence strategy based on horticulture.

It seems, then, that the environmental conditions in southwest Missouri were such that a diffuse economy was the best adaptive system. That the populations there did not participate in the cultural developments going on around them is explained in part by environmental constraint. This, however, should not be interpreted as some cultural deficiency whereby culture changed at a slower rate than should be expected. Rather, the situation should be interpreted as a cultural pattern well adapted to the environment, and which found little need to change.

APPENDIX A

DESCRIPTION OF VARIABLES

Chipped Stone Artifacts

This category includes classes of bifacially worked tools which functioned as either hafted cutting tools or projectiles. They are separated into two major classes: arrow points and darts/knives. This distinction was clear cut, in every case, although the separation was not quantified by weights or measurements. By weight or size, the distribution would probably compare favorably with the bimodal distribution obtained by Fenenga (1953) when he weighed points from sites in Missouri, the western United States, and the Great Plains.

The material used for making these artifacts was chert (of various types). The source of the raw material for each artifact is summarized in Appendix C.

A table summarizing the spatial distribution of the point forms in areas surrounding the study area is presented in Appendix B.

METRIC AND NON-METRIC ATTRIBUTES OF PROJECTILE POINT CLASSES

In order to numerically classify the projectile points from the southwest Missouri tumuli, it was necessary to numerically describe each point. Such measurement and coding will enable two things: (a) statistical comparison of specimens within the present sample, and (b) future statistical comparison of artifacts from the tumuli with similar artifacts from other types of sites within the study area and from sites in surrounding areas. Thus, although many of the assignments of points to classes used in the present analysis have been intuitive, data are presented which would enable comparison on the basis of more objective criteria. Further, many of these data were used to attempt numerical taxonomic classification of specimens.

Most of the measurements used have been used previously by Benfer (1967) and Ahler (1970: 21-24). Ahler stated that "measurements were defined which apply to every artifact, regardless of formal configuration." Although many of his measurements are applicable to the present sample, some revisions, deletions, and additions were made.

The twenty-four point classes were placed in four groups to code their formal attributes. Subtle differences in form within each group necessitated specialized measurements which would discriminate the differences within the group. Yet the attributes which were necessary and sufficient for a full description of each class of points differed slightly. Thus, the four groups are used. These are: (1) dart points, (2) corner-notched arrow points, (3) side- and multiple-notched triangular arrow points, and (4) unnotched arrow points. A brief description of each attribute measured follows. When the attributes are the same for more than one group, the description is not repeated. A generalized figure of a point from each group is used to illustrate the location of the measurements (Figs. 19-22). A summary of the measurements (in millimeters) follows the attribute definitions (Table 19).

1. Total length of lateral margin. Measured perpendicularly from the proximal haft element to the distal blade tip. "In instances of fractured specimens, this measurement (and all other measurements) is estimated on the assumption that the artifact is bilaterally symmetrical...

"2. Basal contact width. The maximum distance between points of tangency on the baseline" (Ahler 1970: 21-22).

3. Basal center point length. The distance from the basal haft element margin to the distal blade tip, measured along the centerline.

"4. Proximal haft element width. The distance between the two points, one on each lateral haft margin, most proximally positioned and at which the orientation of the lateral haft element margin is most nearly parallel to the centerline, measured parallel to the baseline.

"5. Proximal haft element length. The average perpendicular distance from the baseline to the two points on the lateral haft element margins defined in (4).

"6. Distal haft element width. The distance between two points, one on each lateral haft element margin, which are more distally located than the proximal haft element points (4), and at which the orientation of the lateral haft element margin is most nearly parallel to the centerline, measured parallel to the baseline.

"7. Distal haft element length. The average perpendicular distance from the baseline to the two points on the lateral haft element margins defined in (6).

"8. Blade base width. The distance between the two points, one on each lateral blade margin nearest the baseline, measured parallel to the baseline.

"9. Blade base length. The average perpendicular distance from the baseline to the two points defined in (8).

"10. Maximum width. The greatest distance, measured parallel to the baseline, between any two points on the artifact.

"11. Maximum width length. The average perpendicular distance from the baseline to the two points defined in (10).

"12. Maximum thickness. The greatest distance, measured perpendicular to the baseline and centerline, between any two points on the artifact.

"13. Maximum thickness length. The average perpendicular distance from the baseline to the two points defined in (12)....

"16. Basal thinning length. The greatest length of any flake struck from the haft element margin between the two points described in (4), measured perpendicular to the baseline" (Ahler 1970: 22-23).

17. 1/2 Blade width. The distance between two points, one on each lateral blade margin, at 1/4 the distance from the basal contact point(s) to the distal blade tip, measured parallel to the baseline.

18. 1/2 Blade width. The distance between two points, one on each lateral blade margin, at 1/2 the distance from the basal contact point(s) to the distal blade tip, measured parallel to the baseline.

19. 3/4 Blade width. The distance between two points, one on each lateral blade margin, at 3/4 the distance from the basal contact point (s) to the distal blade tip, measured parallel to the baseline.

20. Medial haft width. The distance between two points, one on each lateral haft margin, at 1/2 the distance from the points defined in (4) to the points of basal contact, measured parallel to the baseline.

21. Basal notch width. The distance between two points on the lateral margins of a basal notch at the most proximal part of the notch, measured parallel to the baseline.

TABLE 19

Projectile Point Metrics — Summary Statistics

Type	No. in Sample	No. Measured		Total Length Lateral Margin	Basal Contact Width	Basal Center Point Length	Proximal Haft Element Width	Proximal Haft Length
Rice Side Notched	203	142	Mean Range	63.5 37.5-100.0	14.1 0.0-33.0	63.0 37.5- 98.5	28.5 21.0-38.5	2.9 0.0-5.5
Cooper-like corner-notched	95	79	Mean Range	59.4 38.0-104.5	8.1 0.0-33.0	59.7 38.5-104.0	28.1 20.0-38.0	2.8 0.0-5.5
Guffy-like	11	4	Mean Range	36.9 28.0- 42.0	3.6 0.0-14.5	37.3 28.5- 41.0	21.1 19.5-23.0	2.9 2.0-3.5
McConkey	5	5	Mean Range	44.7 33.0- 55.5	3.6 0.0-18.0	44.9 33.0- 55.5	18.3 13.5-23.5	2.1 1.5-3.5
Delaware-like	3	2	Mean Range	39.5 36.0- 43.0	0.0 0.0- 0.0	41.0 37.0- 45.0	23.8 23.5-24.0	4.8 3.5-6.0
Variant of Rice Side-Notched	8	7	Mean Range	65.1 59.5- 72.0	13.1 0.0-26.0	64.9 58.5- 71.5	21.5 18.5-26.0	1.9 0.0-3.0
Table Rock Stemmed	2	2	Mean Range	64.3 53.5- 75.0	0.0 0.0- 0.0	64.8 54.5- 75.0	11.5 10.0-13.0	.5 0.0-1.0
Cupp	3?	3	Mean Range	83.2 75.0- 92.5	0.0 0.0- 0.0	86.3 77.0- 96.5	21.0 17.0-24.5	4.5 3.5-6.0
Etley-like	3	3	Mean Range	103.7 87.0-114.0	0.0 0.0- 0.0	104.7 88.0-115.0	22.7 20.0-25.0	2.5 2.0-3.0
Gary	8	3	Mean Range	80.7 60.0-105.0	0.0 0.0- 0.0	80.7 60.0-105.0	0.0 0.0- 0.0	0.0 0.0-0.0
Standlee	6	5	Mean Range	55.6 48.0- 65.0	7.8 0.0-11.0	54.6 48.0- 63.5	13.8 8.0-17.0	0.0 0.0-0.0
Afton	2	2	Mean Range	56.8 55.0- 58.5	0.0 0.0- 0.0	58.3 57.0- 59.5	25.5 23.5-27.5	4.0 4.0-4.0
Snyders	2	0	Mean Range	No measurements				
Lander	3	2	Mean Range	76.5 76.0- 77.0	0.0 0.0- 0.0	78.3 78.0- 78.5	29.4 28.5-30.0	2.8 1.5-3.5
Norton	2	1	Mean	55.5	0.0	56.0	25.0	2.5
Marshall	4	1	Mean	65.0	12.0	64.0	20.5	2.5

Type	No. in Sample	No. Measured		Maximum Length	Maximum Width	Maximum Width Length
Fresno	21	17	Mean Range	64.9 38.1- 91.4	34.6 25.4-49.5	9.0 0-34.3
White River Elliptical	12	8	Mean Range	92.2 61.0-121.9	37.6 33.0-49.5	24.8 7.6-53.3
Crisp Ovate	20	14	Mean Range	81.4 57.2-121.9	46.6 35.6-57.2	36.0 22.9-58.4

Distal Haft Width	Distal Haft Length	Blade Base Width	Blade Base Length	Maximum Width	Maximum Width Length	Maximum Thickness	Maximum Thickness Length	Basal Thinning Length
24.0 17.0-34.5	10.8 6.5-16.0	27.2 20.0-35.5	16.6 8.0-23.5	29.0 22.0-38.5	7.3 0.0-46.0	8.3 6.0-11.5	23.7 8.5-51.0	17.5 8.5-31.0
21.6 12.0-28.5	10.7 7.0-17.0	29.2 21.5-38.0	15.6 9.5-21.0	29.9 21.5-38.0	10.8 1.0-33.0	7.8 5.5-10.0	20.8 9.0-43.5	17.9 9.0-28.0
17.6 15.5-18.5	9.9 8.0-12.5	27.0 25.0-29.0	12.1 10.0-14.5	27.0 25.0-29.0	12.1 10.0-14.5	6.4 6.0-6.5	20.3 17.0-22.0	15.5 13.0-21.5
12.5 10.0-15.5	8.3 6.0-10.0	23.2 20.5-28.5	9.6 7.5-12.0	23.2 20.5-28.5	9.6 7.5-12.0	6.3 5.5-7.0	16.0 8.5-28.5	7.7 2.5-10.5
20.5 19.5-21.5	10.8 9.5-12.0	32.8 32.0-33.5	12.0 12.0-12.0	32.8 32.0-33.5	12.0 12.0-12.0	6.8 6.0-7.5	16.5 11.5-21.5	15.5 12.5-18.5
18.4 16.5-21.5	9.1 6.5-15.0	25.6 23.5-28.5	17.1 12.0-30.0	26.3 23.5-29.5	22.4 14.0-30.0	9.8 8.5-12.0	27.6 13.0-42.5	19.3 14.5-30.5
9.5 9.0-10.0	7.5 6.5- 8.5	25.0 23.0-27.0	13.3 13.0-13.5	25.0 23.0-27.0	13.3 13.0-13.5	6.8 6.5- 7.0	15.3 15.0-15.5	12.8 12.5-13.0
13.2 12.0-14.0	12.5 11.5-13.5	28.5 26.5-32.5	17.5 16.0-19.5	28.5 26.5-32.5	17.5 16.0-19.5	7.7 6.0- 9.5	24.2 20.5-27.5	8.8 7.5-10.0
15.3 14.0-17.0	12.5 11.5-14.0	34.3 29.0-37.0	13.3 11.5-16.0	34.1 29.0-37.0	13.3 11.5-16.0	6.2 6.0- 6.5	12.5 11.5-14.5	15.3 10.0-23.0
18.7 13.0-23.0	22.2 17.0-27.5	30.5 24.5-35.0	22.7 17.0-28.0	32.2 24.5-40.0	29.7 17.0-49.0	7.2 6.5- 8.0	36.5 22.5-49.5	12.8 9.5-15.0
19.6 19.0-20.0	16.3 13.0-21.0	28.6 24.0-32.5	18.8 17.0-23.5	28.6 24.0-32.5	19.0 17.0-23.5	7.4 6.0- 9.0	25.2 20.5-29.0	18.5 16.5-21.0
20.0 19.0-21.0	11.8 11.5-12.0	34.3 33.0-35.5	10.3 10.0-10.5	34.3 33.0-35.5	10.3 10.0-10.5	6.3 5.5- 7.0	15.8 14.0-17.5	17.5 15.5-19.5
22.8 20.5-25.0	10.8 10.5-11.0	39.5 39.0-40.0	14.8 14.5-15.0	39.5 39.0-40.0	14.8 14.5-15.0	7.5 7.0- 8.0	31.8 28.5-35.0	26.3 23.5-29.0
18.5	9.0	37.0	10.0	37.0	10.0	6.5	16.0	23.0
18.0	6.5	34.5	6.0	34.5	6.0	8.0	31.5	22.0

1/4 Blade Width	1/2 Blade Width	3/4 Blade Width	Basal Contact Width	Maximum Thickness	Maximum Thickness Length
32.9 24.1-45.7	29.2 21.6-36.8	22.4 16.5-27.9	22.3 0-44.5	8.9 5.1-12.7	21.4 6.4-45.7
36.8 30.5-48.3	34.0 26.7-43.2	26.2 21.6-31.8	0.0 0- 0.0	10.8 7.6-14.0	31.9 11.4-58.4
43.5 34.3-53.3	45.4 33.0-54.6	38.3 22.9-48.3	1.9 0-26.7	15.9 10.2-24.1	34.1 12.7-48.3

TABLE 19: Continued

Projectile Point Metrics – Summary Statistics

Type	No. in Sample	No. Measured		Total Length	Basal Center Length	Basal Contact Width	Proximal Haft Width	Proximal Haft Length	Medial Haft Length	Blade Base Width
Huffaker	47	28	Mean	26.9	26.0	14.2	13.2	6.4	12.4	11.8
			Range	20.3-38.1	18.4-36.2	10.8-16.5	10.2-15.2	4.5-9.5	10.2-15.2	9.5-14.6
Harrell	10	5	Mean	25.5	23.8	12.1	11.7	4.6	11.9	10.5
			Range	20.3-32.4	19.1-29.2	8.9-14.6	8.9-14.6	2.5-6.4	9.5-14.6	8.3-13.3
Washita	7	4	Mean	25.7	25.1	13.7	13.3	5.9	13.7	12.2
				21.6-31.1	21.6-30.5	11.4-15.9	12.1-15.2	5.7-6.4	11.4-15.9	10.8-14.0
Reed	15	6	Mean	21.0	21.2	10.5	10.5	4.5	10.7	10.5
			Range	18.4-22.9	19.1-22.9	8.3-12.7	8.3-12.7	3.2-6.4	8.9-12.7	8.9-12.7

Type	No. in Sample	No. Measured		Total Length Lateral Margin	Basal Contact Width	Basal Center Length	Proximal Haft Width	Proximal Haft Length
Scallorn	412	319	Mean	28.4	2.1	28.6	9.0	1.5
			Range	14.6-67.3	0-12.1	15.2-667	5.7-14.0	0-3.8
Haskell	6	4	Mean	24.3	9.4	23.7	10.5	1.3
			Range	19.7-27.9	8.3-10.8	19.1-27.3	9.5-11.4	1.3-1.3
Keota	5	2	Mean	25.7	0.0	28.9	9.9	4.1
			Range	23.5-27.9	0- 0.0	27.3-30.5	9.5-10.2	3.8-4.5
Late Woodland	8	8	Mean	23.3	0.0	24.2	9.7	1.8
			Range	19.0-29.9	0- 0.0	19.1-31.1	7.6-12.7	.6-3.2

Blade Base Length	Maximum Thickness	Maximum Thickness Length	Basal Notch Width (at Base)	Distal Haft Width	Distal Haft Length	Serration	One Lateral Haft Notch	One Lateral Blade Notch	2 Lateral Blade Notches
9.6 7.6-12.7	3.0 2.5-3.8	8.2 3.8-14.0	1.1 0-3.8	7.1 5.1-10.2	7.9 5.7-11.4	3	22	6	2
7.2 4.5- 9.5	2.9 1.9-3.8	7.4 4.5- 9.5	2.7 1.9-4.5	6.9 5.7- 8.3	6.1 4.5- 8.3	0	0	0	1
9.4 8.3-10.2	3.0 2.5-3.8	8.7 6.4-12.1	0.0 0-0.0	7.0 5.7- 8.9	7.5 7.0- 7.6	0	0	0	0
7.6 6.4- 9.5	2.9 2.5-3.2	8.6 5.1-12.7	0.0 0-0.0	6.8 6.4- 7.6	5.8 4.5- 7.6	0	0	0	0

Distal Haft Width	Distal Haft Length	Blade Base Width	Blade Base Length	Maximum Thickness	Maximum Thickness Length	No. with Minimum Serrations	No. with Maximum Serrations
5.4 3.8-9.5	5.1 3.1-8.3	11.8 5.1-18.4	6.3 3.2- 9.5	3.5 2.5-5.1	9.4 3.2-23.5	141	41
5.7 5.1-6.4	4.3 3.8-5.1	11.6 10.2-12.7	5.1 4.5- 5.7	2.5 1.9-3.2	7.3 6.4- 8.3	0	4
6.4 5.1-7.6	8.0 7.0-8.9	9.9 9.5-10.2	9.9 8.3-11.4	3.5 3.2-3.8	5.1 4.5- 5.7	0	0
6.1 5.1-7.6	5.2 3.8-7.6	11.3 9.5-13.3	7.1 5.1- 9.5	2.5 1.9-3.2	6.8 3.2-13.3	0	3

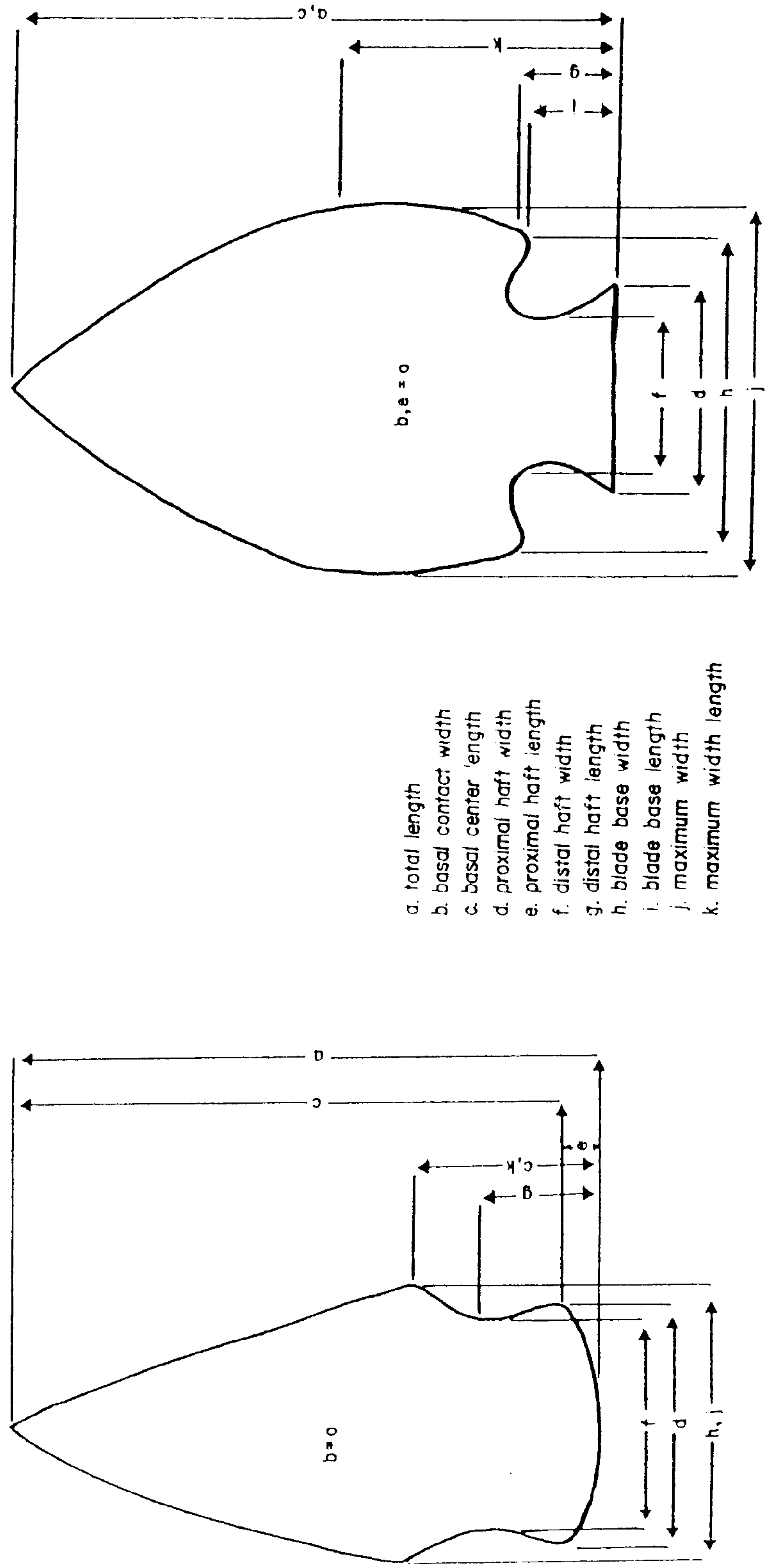
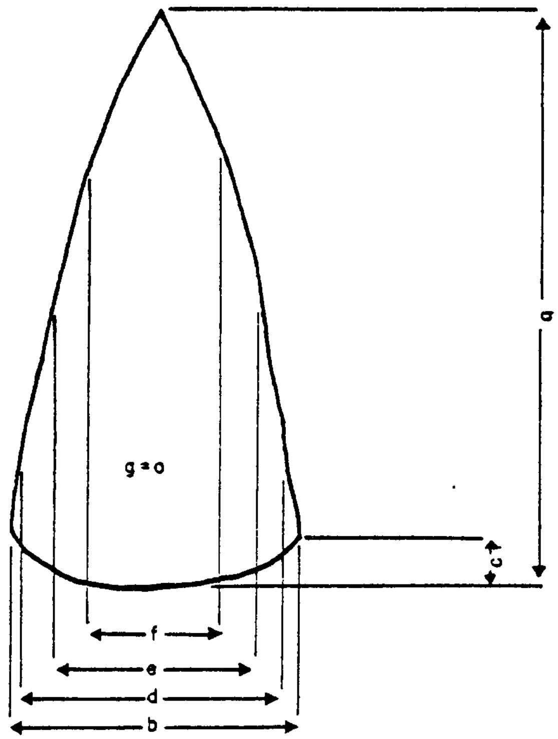
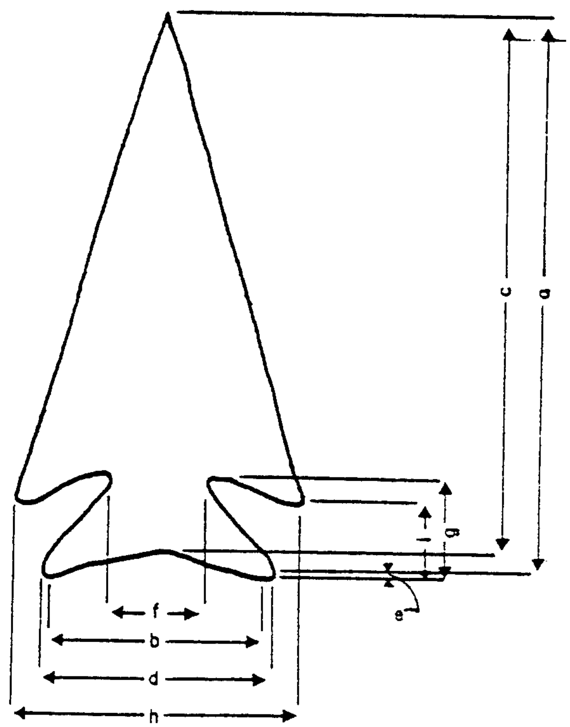


Figure 19. Dart points; measurement loci.



a. maximum length
b. maximum width
c. maximum width length
d. 1/4 blade width
e. 1/2 blade width
f. 3/4 blade width
g. blade contact width

Figure 20. Fresno, White River Elliptical, Crisp Ovate; measurement loci.



a. total length
b. basal contact width
c. basal center length
d. proximal haft width
e. proximal haft length
f. distal haft width
g. distal haft length
h. blade base width
i. blade base length

Figure 21. Scallorn, Haskell, Keota, Late Woodland; measurement loci.

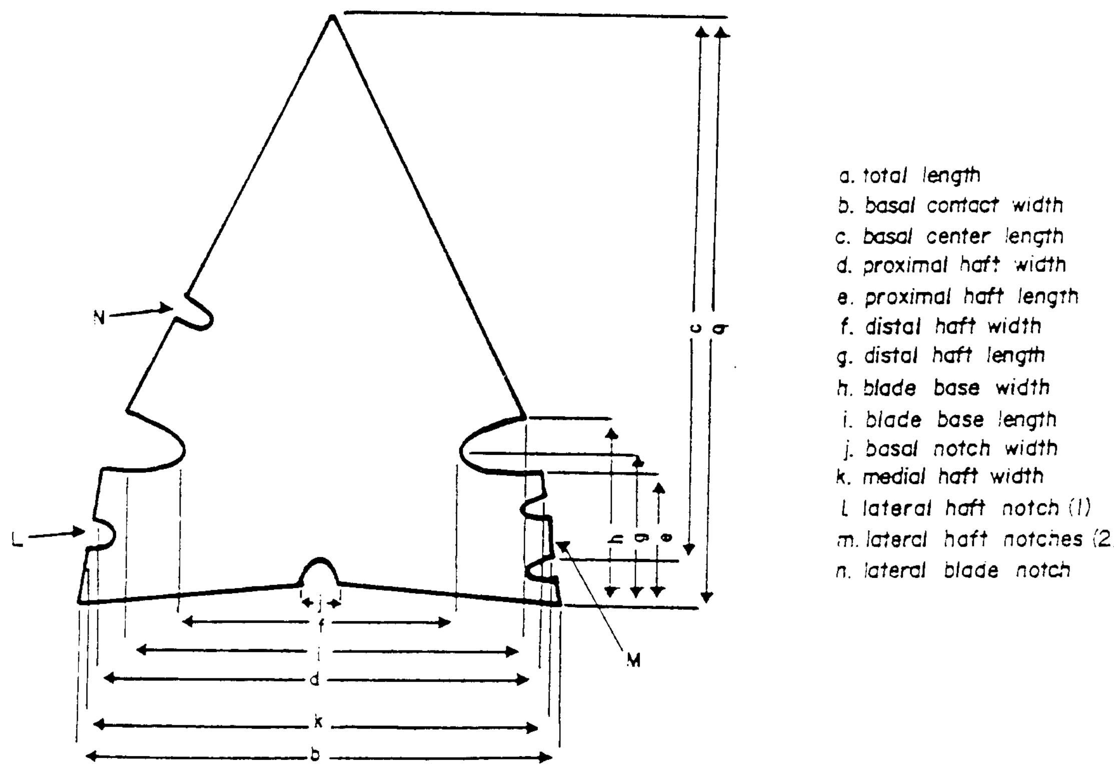


Figure 22. Huffaker, Harrell, Washita, Reed; measurement loci.

22. Lateral notches. Extra set or sets of notches, occurring in addition to the primary set of notches, found on the lateral margin of either the blade or haft element.

23. Serrations. Small flakes removed by pressure flaking to produce a scalloping on the lateral margin of the blade and sometimes haft element. Two forms, minimal and maximal, distinguished here on the basis of the depth and distinctness of the serrations: a subjective determination.

DESCRIPTIONS

SCALLORN: 412 specimens (Plate 3, g-q)

Basic description: A small corner-notched arrow point with a triangular, often serrated blade, straight to barbed shoulders, and an expanding stem.

Blade: Triangular with straight or slightly convex edges. Thin bi-convex cross-section. Approximately one-fourth have serrated edges; serration ranges from almost none (possibly flake scars from pressure retouch), to well-formed, precise and even nodes.

Shoulders: Range from nearly straight to heavily barbed. Angular with straight outline.

Notches: Broad to medium U-shaped, inserted at a 30° to 60° angle to the medial axis.

Stem: Moderately to very sharply expanding with concave outline.

Base: Ranges from subconcave to extremely convex. Corners usually angular, but in convex based specimens corners are rounded.

Comments: The Scallorn category includes arrow points with a wide range of formal attributes. Included in this category are points which resemble Sequoyah points identified by James A. Brown from the Spiro Site collections. Perino (1968: 88) describes Sequoyah as a generally narrower point with serrated blade edges and a bulbous base. He states that Scallorn and Sequoyah can be confused. In an attempt to discriminate between the two forms, a cluster analysis was performed on the present sample. Fifteen measurements (see Fig. 21 and Table 19) were taken on each of the 319 points complete enough to be measured. The data were then standardized by column to remove the effects of size and to enable comparison of the shape of the tools. A cluster analysis was then done using the BMD program (Dixon and Brown 1977). The technique used was average linkage which uses an average of

the distance of units within each cluster formed, while accounting for and removing the effects of the number of members in the cluster.

This program does not calculate a cophenetic correlation, the index of similarity between the data in original space and reduced space. However, the cophenetic correlation probably would have been low, given the number of reversals in the clustering sequence (i.e., groups joining into clusters at a shorter distance than the distance between the groups which previously clustered). A low cophenetic correlation would mean that the artifacts cannot be reasonably reduced into a heirarchical ordering.

The resultant phenograph from the analysis (Fig. 23) shows that there are no tight clusters of similar points. Rather, there is a continuum of forms. The results seem to indicate that either aboriginally there was a single template for manufacture of these points, or that there were several different competing templates (perhaps spatially, temporally, or culturally distinct). In either case, the cluster analysis shows that even if knappers were attempting to produce a desired form, be it one, or one of several, that goal was never fully achieved. What appears, then, are a number of different forms which when compared to some others are formally and statistically distinct (i.e., those at one end of the range are clearly different than those at the other end), but when put into a sample with all possible forms, lose their distinctiveness. There may be different forms in the sample, but there are so many points which are intermediate in form that all the points must be regarded as being similar enough to be from one population or type. This indicates that types such as Sequoyah and Scallorn used previously in the literature may be artificial, culturally insignificant separations. At least, this seems to be the case for the given sample, and so all 319 points are placed in one class: Scallorn.

Suhm, Krieger, and Jelks (1954: 84) allow Scallorn points a time range from about A.D. 700 to 1500. Sequoyah points, subsumed here under the Scallorn class, are dated from about A.D. 1000 to 1350 at the Spiro site. Scallorn points are widely distributed, occurring throughout Texas, Oklahoma, Missouri in most sections of the Mississippi Valley, and onto the Central Plains. In southwest Missouri they are the most common of all arrow points. Thirty-eight were recovered from open sites during surface survey in Truman Reservoir and many more have been recovered from shelters (Roper, personal communication).

FIGURE NOT AVAILABLE

Figure 23. Cluster analysis of 319 Scallorn points.

HASKELL: 6 specimens (Plate 3, r-s)

Basic description: A small, extremely well flaked, side-notched point with a subconcave base.

Blade: Triangular with straight edges. Blades on all specimens are finely serrated. Very thin biconvex cross-section.

Shoulders: Weak and concave in outline.

Notches: Deep narrow notches inserted very near the base at an 80° angle to the medial axis.

Stem: Rounded lateral margins. Haft element slightly narrower than the distal blade portion.

Base: Subconcave with rounded corners.

Comments: Haskell points were named from specimens at the Spiro site, Oklahoma by J. A. Brown (1968). The point is known to occur in eastern Oklahoma and western Arkansas, as well as in Illinois Cahokia sites.

Haskell points are affiliated with the Spiro phase occupation at the Spiro site, thereby placing them in the temporal span between A.D. 1200-1350 (Perino 1968: 32).

KEOTA: 5 specimens (Plate 3, bb)

Basic description: A small, side-notched arrow point with a convex base.

Blade: Triangular with irregular edges. Medium thickness; bi-convex in cross-section.

Shoulders: Weak angular to rounded.

Notches: Moderately deep, rounded notches inserted at a 90° angle to the medial axis.

Stem: Sharply expanding with straight to convex outline, then rounding towards the base.

Base: Convex with rounded angular corners.

Comments: Keota points were named by J. A. Brown (1968) from points at the Spiro site, Oklahoma. Their distribution is in eastern Oklahoma and western Arkansas. The Keota points are associated with the Spiro phase occupation at the Spiro

site, from approximately A.D. 1200-1350, and are often found there with Haskell points.

Late Woodland: 8 specimens (Plate 3, a-b)

A complete formal description of this class would entail an individual description of each specimen. Rather, a general description of the class is presented.

Basic description: A small corner or side notched arrow point distinguished by its manufacture from a flake with retouch confined mostly to the edge. Most are crudely made, often on a curved or twisted flake. The point outline is similar to those of Scallorn or Reed points. Four points are side-notched. Blades are either straight-or convex-sided triangular forms. Shoulders are both rounded and sharply angular.

Comments: It is unknown whether this point form (or, more precisely, manufacture technique) is a culturally meaningful class. Perino (1971: 100) has defined three types similar to these: Klunk Side-Notched, Koster Corner-Notched, and Schild Spike points. All are attributed to the Late Woodland period and are found from St. Louis, Missouri, northward into Illinois and westward to central Missouri. He dates them from A.D. 600 to A.D. 900. The points in this class from southwest Missouri can only tentatively be considered associated with Perino's types: they may either result from the poor execution of some other arrow point type or represent idiosyncratic behavior.

FRESNO: 21 specimens (Plate 3, e-f)

Basic description: A small triangular unnotched arrow point with a straight or subconcave base.

Blade: Triangular with edges either straight or slightly convex. Moderately thin biconvex or plano-convex cross-section. Blade not always totally retouched on both surfaces.

Shoulders, notches, stem: None

Base: Either straight with rounded corners or subconcave with sharply angular corners.

Comments: Many archeological point classifications include subdivisions of the points classified here as Fresno points. For example, Purrington (1971) distinguished between points with three straight sides (Fresno), two straight sides

with a concave base (Maud), and two excurvate sides with a straight base (API). These sub-types may simply represent regional variants of the simple triangular form. Since this variation has not been well delimited or quantified, all three subtypes are combined into one class for the present analysis.

Because of the simple form of the Fresno point and its widespread distribution, it is impossible to use this point form as an indicator of cultural affiliation. Simple triangular points are found throughout North America and in some places "was undoubtedly independently derived" (Purrington 1971: 73). Even though the Fresno point is a widespread type, its age affiliation is more clearcut. In most regions it is usually found in late prehistoric contexts, and commonly associated with Mississippian pattern cultures (Bell 1960: 44). Suhm and Krieger (1954: 498) assign its temporal range from A.D. 800 or 900 to A.D. 1600 or later. The 14 specimens collected during the Truman survey make Fresno the second most common type of arrow point, Scallorn being the most common.

WHITE RIVER ELLIPTICAL: 12 specimens (Plate 3, cc-dd)

Basic description: A small, norrow, thin ovate tool.

Blade: Narrow, generally symmetrical excurvate outline, with a sometimes reworked tip. Cross-section is moderately thin, usually bi-convex, but occasionally plano-convex. Sometimes made from a flake which retains some of its original twist. Flaking is of good quality, edges continuously retouched, and only occasionally is there any original flake surface which is unmodified.

Shoulders, stem, notches: None

Base: Subconvex to convex. There is a gradation in types of corner form: from distinct but rounded corners, to no actual corners; the blade edge continuous with the base.

Comments: It is difficult to classify small ovate blades from the tumuli in southwest Missouri. Previously named types such as White River Elliptical, Crisp Ovate, and the more widely used Young seemed poorly defined, with diagnostic attributes often overlapping. Two type names are used in the present classification: White River Elliptical and Crisp Ovate. Although not all specimens fit within classic definitions of these types, definitions of those two types best describe the attributes which clearly separate the present sample into two distinct classes (based on a

cluster analysis of White River Elliptical, Crisp Ovate, and Fresno specimens not presented).

White River Elliptical was first described and named by Bray (1956: 125) from specimens from the Rice Site. His type included only those points with pointed bases, much like Nodena points from the Mississippi Valley. Later, Marshall (1958: 133) expanded Bray's definition to include more rounded based forms which did not have such fine secondary retouch. The present sample, although mostly finely retouched, does not have the pointed bases described by Bray. In that these have rounded bases, they best fit within Marshall's type description. Included in the White River Elliptical class are some points which some archeologists might classify as Young points.

The function of these artifacts is uncertain. The fine retouch and the size are reminiscent of other small arrow points. However, the shape and the lack of notches might indicate that they were used as knives. Further analysis of wear patterns may give an indication of their function.

Areal distribution of these tools is unknown. They occur throughout southwest Missouri and Oklahoma. Both Purrington (1971: 77) and Marshall (1958: 134) assign White River Elliptical to a Mississippian period, although Purrington states that in Oklahoma they consistently appear in slightly deeper levels than do other small triangular notched arrow points.

CRISP OVATE: 20 specimens (Plate 3, mm-nn)

Basic description: A medium sized irregular shaped, ovate tool.

Blade: Roughly shaped, but nearly symmetrical, ovate blade. Both faces not always fully retouched. Retouch is crude, with large flakes shaping the blade. Blade is usually not well thinned, with a hump created as the result of incomplete modification. Cross-section is thick and as often plano-convex as bi-convex. Only a few specimens have a well defined tip.

Shoulders, stem, notches: None

Base: Convex, usually grading directly into the blade edges, but occasionally cornered, though well rounded.

Comments: Some of these blades might be classified by others as Young points. However, they are thicker and larger

than the Young point descriptions imply. Some have outlines similar to White River Elliptical points, but all are thicker, more asymmetrical, and not as finely retouched as those points classified here as White River Elliptical.

There is some question as to the function of these tools. They may have functioned as dart points or as knives. There is also the possibility that they are merely preforms for small arrow points.

The distribution of Crisp Ovate is not presently known. Possibly artifacts of this form are not always reported and described with other projectile points: they might instead be considered as small bifacially worked tools.

Marshall (1958: 134) states that Crisp Ovate is affiliated with Late Woodland and Mississippian horizons in southwest Missouri.

HUFFAKER: 47 specimens (Plate 3, t-w)

Basic description: A small triangular arrow point with side notches and at least one extra pair of notches on the lateral margins of the haft element.

Blade: Triangular with straight edges. Four points have finely serrated edges. Two other points have an additional pair of notches on the blade 1/3 the distance from the main notch and the tip. Cross-section is thin to medium bi-convex.

Shoulders: Usually straight and angular, but occasionally rounded.

Notches: The main pair of notches are narrow and deep inserted at approximately a 90° angle, about 1/3 the distance between the base and the tip. On the lateral margins of the haft element, there are usually one, but sometimes, two, other pairs of smaller notches.

Stem: Expanding with an irregular outline caused by the additional notching.

Base: From subconvex to subconcave, often straight. About 1/3 of the specimens have a small basal notch at the midline.

Comments: The Huffaker point was named by Baerreis (1954: 44) in northeastern Oklahoma. The point is found throughout Oklahoma and most of the Plains and eastward to Illinois (Bell 1960: 58).

Huffaker points seem to be a rather late prehistoric type, associated with Harrell, Washita, and Fresno types of Spiro focus sites. The age range is approximately A.D. 1000 to A.D. 1500 (Bell 1960: 58).

CAHOKIA OR HARRELL: 10 specimens (Plate 3, x-y)

Basic description: A small triangular arrow point with small side notches inserted fairly highly on the blade and a basal notch.

Blade: Triangular with nearly straight edges. Thin biconvex cross-section.

Shoulders: Straight with angular corners.

Notches: Very small, narrow side notches inserted at a 90° to 110° angle to the medial axis, usually at a 90° angle to the lateral margin. Notches are approximately 1/4 the distance from the base to the tip.

Stem: Continuous line with that of the blade.

Base: Straight or subconcave line broken by a small notch on the medial axis.

Comments: Suhm and Krieger (1954: 500) separate these from Washita points on the basis of the basal notch on Harrell points. Bell (1958: 30) states that Harrell points are similar to and may not be separable from Cahokia points. Perino (1968: 12), however, believes that Cahokia points "are generally longer and wider and most of the side notches are at right angles to the sides rather than parallel with the base." A separation on the basis of these attributes would be possible in the present sample, but a larger sample is needed to quantify this distinction.

These points are widely distributed throughout North America. They are found in the Great Plains, east to the Mississippi Valley, and west to the Southwest (Bell 1958: 30). If indeed Cahokia points are different, their distribution may be more limited. Perino (1968: 12) states that they are found at the Cahokia site in Illinois and the Aztalan site in Wisconsin, as well as on most Cahokia-affiliated sites and sites along Caddo-Mississippian trade routes.

The age of these points ranges from A.D. 900 to late prehistoric times. In Oklahoma the Harrell point does not appear to last into historic times (Bell (1958: 30).

WASHITA: 7 specimens (Plate 3, zz-aa)

Basic description: A small triangular arrow point with small deep side notches inserted fairly highly on the blade.

Blade: Triangular with nearly straight edges. Very thin biconvex cross-section.

Shoulders: Straight with angular corners.

Notches: Narrow, but deep side notches inserted at approximately 90° angle to the medial axis about 1/3 the distance from the base to the tip.

Stem: Nearly continuous line with that of the blade; slightly expanding.

Base: Subconcave with angular corners.

Comments: Suhm and Krieger (1954: 500) name this point as a subtype of the Harrell point. The Washita is similar except for the Harrell's basal notch. The two are often found in association. Washita points are abundant in central and western Oklahoma and are found throughout most parts of the Great Plains, as well as the Mississippi Valley and the Southwest. The estimated time range is from A.D. 1100 or 1200 to A.D. 1500 or 1600. It tends to be associated with sedentary, agricultural populations (Bell 1958: 98).

REED: 15 specimens (Plate 3, c-d)

Basic description: A small triangular arrow point with shallow side-notches near the base.

Blade: Triangular with straight sides. Thin to medium biconvex cross-section.

Shoulders: Straight with concave edges.

Notches: Shallow, moderately wide notches inserted at near a 90° angle to the medial axis. Notches found at approximately 1/4 the distance between the base and the tip.

Base: Almost straight with rounded corners and lateral haft margins which contract slightly toward the notches.

Comments: With the exception of one specimen, all are of poor manufacture. The points are asymmetrical with very little retouch.

The Reed type has been described by Baerreis (1954: 44) and Bell (1958: 76). Neither was able to fully describe its spatial distribution. Many are found in Oklahoma where the point type was first named. Marshall (1958: 132) describes a type (Jakie Notched) from the Table Rock Reservoir area which is similar. Two Reed points were recovered during shelter excavations in the area and several have been found during Truman Reservoir survey in open sites (Roper, personal communication).

Reed points in Oklahoma have been found in Caddoan assemblages. An estimated range has been given by Bell (1958: 76) as A.D. 500 up to A.D. 1500.

RICE SIDE-NOTCHED: 203 specimens (Plate 1, a-h)

Basic description: A broad, fairly thick, triangular dart point with very shallow, broad side-notches and nearly straight base.

Blade: Triangular with either straight or convex edges. Quality of flaking tends to be poor, with mostly percussion flaking and little retouch, leaving edges fairly irregular. Cross-section is moderately thick and irregularly bi-convex. Many have been reworked, leaving a short stubby blade.

Shoulders: Poorly defined, weak and rounded often grading directly into the shallow side-notches.

Notches: Very shallow, broad, inserted at approximately 90° to the medial axis and often asymmetrical. Sometimes appears as just a slight constriction in the width of the point.

Stem: Very broad, expanding with either a concave or nearly straight outline.

Base: Usually straight, but occasionally slightly subconcave or subconvex. Corners are usually irregularly rounded and sometimes bulbous or flaring.

Comments: Rice Side-Notched points and those points from the tumuli classified here as Cooper-like corner-notched points are very similar in a number of formal attributes. The two classes grade into one another and assignment of some specimens into one or the other class was difficult. A further discussion of the similarities of attributes will follow the description of the Cooper-Like corner-notched points.

Rice Side-Notched points were named by Bray (1956) from specimens at the Rice Site. Dart points of this type seem to be most abundant in southwest Missouri, although they occur in small numbers in immediately surrounding areas. They are so ubiquitous in the tumuli, that Wood (1961, 1967) uses Rice Side-Notched points, along with Scallorn arrow points, as diagnostic traits of the Fristoe Burial Complex. They are abundant in open and shelter sites in southwest Missouri as well. One of the most numerous of all dart points recovered in the Truman Survey, they are second only to Langtry (Standlee) points in frequency of occurrence. Rice Side-Notched points also occur in smaller numbers in Oklahoma (Purrington 1971: 96), northward to the Missouri River and Kansas City (Shippee 1967) and eastward in the Gasconade River area (McMillan 1965b).

Most archeologists working in and around southwest Missouri tend to treat the Rice Side-Notched points as a regionally isolated type. It is true that in many of its attributes (especially the shallowness of the notches and crudeness of workmanship) it seems to be unique. However, the Rice Side-Notched type bears a formal resemblance to Ansell, a type originally named from Illinois specimens (Montet-White 1968). There is also a resemblance between the Cooper-like corner notched points and Stueben points (Morse 1963) from Illinois. It is also striking that the relationship which holds between Rice Side-Notched points and Cooper-like corner-notched points, in terms of form and co-occurrence, seems to hold true for Ansell and Stueben points. Montet-White (1968: 75) states that Ansell "points are closely related to the Stueben stemmed with which they are often associated. Within single components, these two types of points cannot be separated on the basis of metric attributes."

Both Ansell and Stueben points are found on late Middle and Late Woodland sites in Illinois, Missouri, and Iowa, thus dating around A.D. 500. A similar temporal placement, in the Late Woodland period, has been postulated for the Rice Side-Notched type.

Cooper-Like Corner-Notched: 95 specimens (Plate 1, i-o)

Basic description: A medium-sized dart point with a broad blade, broad corner-, or sometimes side-, notches and a weak to angular shoulder.

Blade: Ovate to triangular with convex or occasionally straight edges. Blade edges are usually symmetrical. Cross-section moderately thin and bi-convex.

Shoulders: Weak, but easily distinguishable and slightly angular or rounded.

Notches: Very broad and shallow. Vary from well rounded to angular upside-down J-shaped. Angle of notch insertion varies greatly between 45° and 80° and is difficult to ascertain.

Stem: Moderately to sharply expanding with concave to almost straight outline.

Base: Subconvex to straight. On a few specimens there is a very shallow indentation at the midline. Corners are angular, but rounded. Basal width varies from being slightly wider than the shoulder width to a few millimeters narrower than the shoulder width.

Comments: The Cooper-like corner-notched group is sometimes difficult to distinguish from the Rice Side-Notched specimens. There is great variability within both classes of dart points, so that most specimens from one class differ greatly in form from most points of the other class. However, the classes do tend to grade into one another.

Rather than combine both classes to form one analytic unit, it seemed necessary, for several reasons, to retain two categories. Although there is a continuum in the form of the points from the most extreme side-notched points to the most corner-notched points, the points at either end of the scale have enough dissimilar attributes that they seem to represent the product of totally different behavioral intentions. Furthermore, throughout the archeological literature of the region, both Rice Side-Notched and Cooper Corner-Notched (or Snyders-like [Denny 1964] or Rice Corner-Notched [Marshall 1958]) types have been used as analytical units. Purrington (1971) makes a good case, although not explicitly, for retaining two separate categories. In Delaware County, Oklahoma, the two types appear to have cultural independence. At nine sites reported by Purrington, Cooper points were present while Rice Side-Notched points were absent. In two of the four sites where both occur, Cooper points were found stratigraphically earlier than the levels in which the two types co-occurred. Furthermore, Rice Side-Notched points were never abundant in any site, while Cooper points were fairly numerous. Such differences in frequency of occurrence seems to be a regional phenomenon, because in southwest Missouri Rice Side-Notched are more ubiquitous than the Cooper Corner-Notched. So, it appears that there may be regional, temporal, and perhaps functional variation between the two point types. For this reason, an attempt was made to find some valid means for distinguishing between the types and identifying the present specimens as being one or the

other type. Two means to this end were attempted. The first was a numerical classification and the second was a gross morphological intuitive classification. The two classifications compare favorably and a discussion of the different results which follows is instructive.

An attempt was made to numerically classify this sample of dart points. Fourteen measurements were coded for each point (Fig. 19 and Table 19). The data were standardized by column to remove the effects of size in the subsequent evaluation of similarities between dart points. A cluster analysis was then performed using the Numerical Taxonomy System (Rohlf, Kishpaugh, and Kirk 1972). The type of linkage used was the unweighted pair group method of arithmetic UPGMA), an averaging technique. This technique uses an average of the distances of units within each cluster formed, while accounting for an removing the effects of the number of members in the cluster; this average is then used in the calculation of similarities for formation of subsequent clusters. UPGMA gave better results than either single or complete linkage, or WPGMA.

The phenogram produced by the program is presented (Fig. 24). A cophenetic correlation of .795 suggests that one dimensional space (i.e., the phenogram) is not wholly adequate for representing the relationship among specimens in the present sample. Examining the dendrogram, a division of the 221 points into two groups can be made (as shown by dotted line in Figure 24). This separation will be important in later discussion of the typological classes to be used in the factor analysis. It can be seen, however, that this separation is not very distinct. Throughout the polythetic agglomerative process which resulted in the present numerical classification, much chaining has occurred. This, coupled with the low cophenetic correlation, indicates that on the basis of the 14 variables used, no distinct patterning (i.e., clearly distinguishable, distinct groups of similar projectile points) occurs. Perhaps the analysis contains several variables (such as thickness, basal thinning, and length) which are shared by all dart points, or which were beyond the control of the artifact manufacturers. It seems that there are at least two basic point types (i.e., in terms of morphology of point outline and notch form), but that the ability of the numerical classification to distinguish between them is hampered by the addition of variables which were perhaps not culturally significant and randomly occurring.

After completing the numerical classification of these 221 points, a more classic method of classification was attempted, viz., separation on the basis of the gross morphology of the point outline and especially, the haft element, thus producing a subjective, non-metric classification. Four

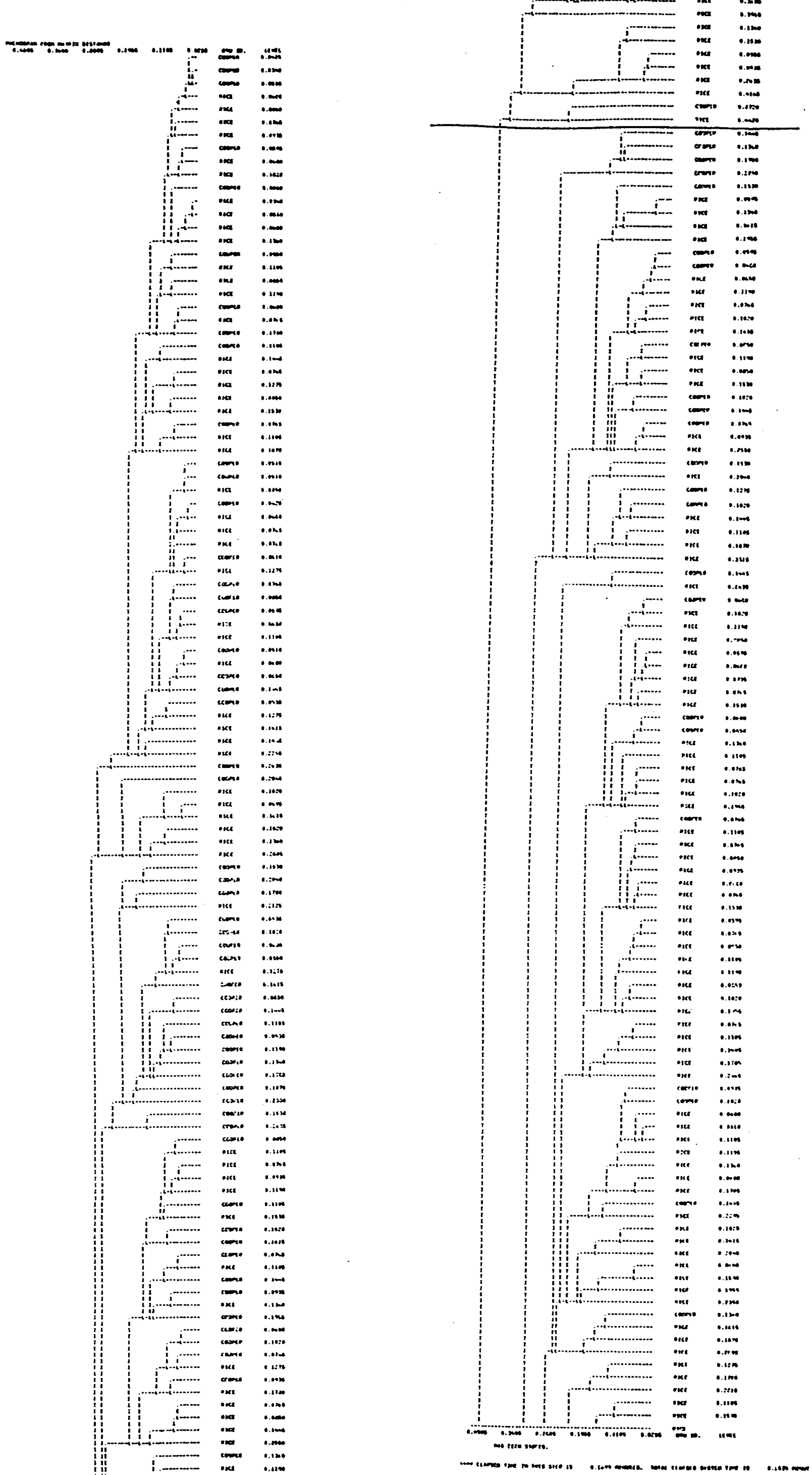


Figure 24. Cluster analysis of Rice Side-Notched, and Cooper-like corner-notched points.

major attributes were used as the distinguishing criteria for separation; all are attributes of the haft element and particularly of notching technique. Rice Side-Notched points have a poorly defined shoulder while the Cooper-like Corner-Notched points clearly have a shoulder, even though it is sometimes a rounded angular form. The shoulder attribute seems to depend on the depth and angle of the notch, the second and third attributes. Rice Side-Notched points have a very shallow notch, sometimes just a slight contraction, inserted at a 90° angle, while the Cooper-like Corner-Notched points have a slightly deeper notch which is sometimes angular and inserted from more near the corner. Also related to this difference in notch form is the proximal haft element, the fourth distinguishing criterion. The Rice Side-Notched proximal haft elements (or basal corners) are usually irregularly rounded, almost bulbous, whereas the Cooper-like points have more angular, though rounded, symmetrical basal corners. On the average, the Rice points are cruder, asymmetrical and fairly thick. The Cooper-like points show much finer workmanship.

Next, a comparison was made between the two classifications of the 221 points. Each point was labeled on the phenogram (Fig. 24). It is apparent that the two classification schemes are not totally in concurrence. To test whether the degree of concurrence was statistically significant, a chi-square test was carried out. The distribution of Rice and Cooper points (as categorized intuitively) in the final two clusters formed during the numerical classification (see dotted line in Fig. 24) was tested for randomness. The first group of points contained 78 Rice points and 23 Cooper points. The second group contained 64 Rice points and 56 Cooper points. The 2x2 contingency test resulted in a chi-square value of 13.82. With one degree of freedom, there is less than .001 chance that such a distribution could occur by chance alone. So, even though neither cluster in the numerical classification is exclusively composed of either Rice or Cooper, the comparability of the numerically and intuitively conceived classifications is statistically significant.

The second, or gross morphological, classification is chosen here as the basis for class formation for subsequent analysis. This decision has two bases. First, too much variability may have been introduced into the numerical classification. Whether the variability present in the artifacts represents real, culturally intentional differences in form is unknown. Speaking from hindsight, it seems invalid to give equal weight (which numerical taxonomy does in this analysis) to variables such as thickness (which may be uncontrollable by the manufactures) and length (which may be affected by use and retouch) in a stylistic analysis. In essence, then, to use the results from numerical taxonomy

would be to use more information to categorize these two classes of dart points than was used to categorize other classes of artifacts. Second, the two classes, Rice Side-Notched and Cooper Corner-Notched, have been used extensively in other cultural-historical analyses in the area. Because the dart points in the present sample compare favorably to the previously defined types, these classes will be retained for the following factor analysis.

The dart points classified here as Cooper-like Corner-Notch have been given that name because of their affinity to Cooper points, a ubiquitous type from the Cooper sites in northeast Oklahoma (see Purrington, 1971: 98-103). The class name used here is a qualified one; Cooper-like. This is to indicate that there is a broader range of point forms represented in this class than in Purrington's (1971: 98-103) Cooper type. Although many of the tumuli dart points clearly fit within Purrington's type description, others are either less ovate (more long and slender) or have slightly more angular notches than the classic Cooper type. Inclusion of such points into the Cooper-like category was based on the fact that although there is a wide range of variability in form, there seems to be a continuous gradation in the variability; none of the forms seem to represent discrete formal types.

Both the points in the tumulus sample and the Cooper points from Oklahoma resemble corner-notched points from Kansas City Hopewell sites (Shippee 1967) and from other sites in Woodland phases in Kansas (e.g., Cuesta Phase [Marshall 1972] and Grasshopper Falls Phase [Reynolds 1979]). A similar resemblance occurs between several of the Cooper-like points and Steuben points (Morse 1963) from Illinois.

Cooper points from Oklahoma are found in post-Archaic contexts, continuing into the Spiro and Neosho foci (Purrington 1971: 102). Kansas City Hopewell sites, with similar points, date between A.D. 1 and A.D. 500 (Johnson 1976), the period of the Havana Tradition of the Middle Woodland Period in Illinois. The Steuben points, which also resemble some of the specimens in the present sample, date to a later period in Illinois — the late Hopewell and early Late Woodland periods. It seems that the formal variability found in the Cooper-like points may be indicative of changes in style, through time just as dart form changes slightly in Illinois points from the Middle to the Late Woodland periods.

Variant of RICE SIDE-NOTCHED: 8 specimens (Plate 2, a-b)

Basic Description: A convex sided, thick dart point or knife, with a gradual constriction near the base, and a

flaring base which is narrower than the maximum width of the blade.

Blade: Ovate blade with convex edges. Thick, fairly irregular bi-convex cross-section.

Shoulders: In all but two specimens shoulders are very poorly defined. There is a gradual tapering from the blade into a constriction which serves as the notching. Two points have weak, rounded shoulders.

Notches: Very shallow, broad, constriction, rather than distinct notches. On three specimens, constriction is high on the point, approximately one third the distance from the base to the tip. The other five points have the constriction very near the base.

Stem: Very short and expanding, with concave or straight outline.

Base: Straight, but irregular due to poor control of thinning flaking. Angular corners, occasionally rounded.

Comments: These are rather similar to the Rice Side-Notched points previously described, in that they, too, are shallow side-notched dart points. However, they are metrically distinct enough from Rice Side-Notched to warrant a separate category (on the basis of a cluster analysis, not presented here). Most exhibit fairly crude workmanship. The notches are very indistinct, shallow constrictions, with little or no retouch. All of the blades are very thick; many have a medial ridge where thinning was unsuccessful. The function of these tools is unclear: some of them may in fact be unfinished dart points, due to inability to properly thin the blade. Others may have functioned as either dart points or hafted knives.

This variant of the Rice Side-Notched type is either unique to the burial tumuli in southwest Missouri, or tools of this type have not been included in published artifact descriptions. None exist in the Truman Reservoir surface survey collections, among excavated materials from open sites or shelters, or in sites outside of southwest Missouri.

No temporal placement of this variant can be given, although their time range may be similar to that of the other Rice Side-Notched points.

Guffy-Like: 11 specimens (Plate 2, h)

Basic description: A medium sized triangular bladed point with moderately barbed shoulders, U-shaped corner notches and nearly straight base.

Blade: Triangular with straight to convex edges. Fairly thin biconvex cross-section.

Shoulders: Moderately to strongly barbed with concave outline.

Notches: Fairly deep, narrow U-shaped notches inserted at approximately 30° angle to the medial axis.

Stem: Moderately expanding with straight or slightly concave edges.

Base: Straight or subconvex, but irregular due to poor thinning technique.

Comments: Guffy points were defined from specimens in Oklahoma by McHugh (1963: 63-6). The points classified here as Guffy-like are similar to the type description with the exception of the barbs. Most of the tumuli points are less strongly barbed than the Oklahoma Guffy points. Points similar to these have been found in the Ozarks and have been called CN10 by McMillan (1965b: 93-4) in the Gasconade area, and Kings Corner Notched by Marshall (1958: 127) in the Table Rock Reservoir area.

Guffy points in Oklahoma are abundant in Grove components (placed within the Late Archaic period) but are also present in the later Delaware, Caddoan, and Neosho foci (Purrington 1971: 126). McMillan (1965b) assigns these points to the Late Archaic, while Marshall (1958) gives a time range from the Middle Archaic into the marginal Mississippian period.

McCONKEY: 5 specimens (Plate 2, j-k)

Basic description: Small to medium dart point with a triangular blade, broad corner notches, barbed shoulders, and a sharply expanding stem.

Blade: Triangular with straight to sub-concave edges. Cross-section is biconvex.

Shoulders: Moderately to strongly barbed with concave outline.

Notches: Fairly deep, prominent U-shaped notches, inserted at approximately 45° to the medial axis.

Stem: Sharply expanding with straight to concave outline.

Base: Nearly straight, sometimes irregular with pointed corners.

Comments: The McConkey point was named by McHugh (1963: 93-4) from points in Oklahoma. Marshall (1958: 125-7) has included them in his Kings Corner-Notched type, in Missouri. Purrington (1971: 137) assigns them to an early burial mound period in Oklahoma, along with Table Rock Stemmed points, and indicates that they may also continue into the Temple Mound period.

Delaware-Like: 3 specimens (Plate 2, f)

Basic description: A broad, short, ovate bladed point, with deep U-shaped corner notches, strong barb, and a subconvex base.

Blade: Short, ovate, broad, with irregular, convex edges. Thick, irregular, biconvex cross-section.

Shoulders: Strong, but irregularly shaped barbs, concave in outline.

Notches: Very deep, fairly narrow U-shaped, inserted at approximately 30° to medial axis.

Stem: Moderately expanding with straight edges.

Base: Subconvex with rounded corners.

Comments: Delaware points were defined by Purrington (1971: 124) on the basis of a sample from Delaware County, Oklahoma. He states that "they have about the same time range as the Guffy points, being characteristic of the Grove C Focus." It is unclear in Oklahoma whether the Delaware points, like the Guffy points, continue into the later Delaware, Caddo, and Neosho components.

MARSHALL: 4 specimens (Plate 2, i)

Basic description: A broad, medium sized point, with strong barbs, deep basal notches, expanding stem, and a straight base.

Blade: Broad, excurvate to triangular with straight edges. Fairly thin, biconvex cross-section.

Shoulders: Strong broad, flat and thin barbs. Barbs are rounded and do not reach to the point base.

Notches: Narrow, deep, U-shaped inserted at approximately 25° to the medial axis.

Stem: Slightly expanding, straight to slightly concave edges.

Base: Irregular, but straight. Very thin, with angular corners.

Comments: Suhm, Krieger and Jelks (1954: 444) and Bell (1958: 44) have described Marshall points. In Texas and Oklahoma, Bell (1958: 44) assigns Marshall to the Archaic period; McMillan (1965b: 97) assigns them to the Late Archaic in the Gasconade drainage of Missouri. Purrington (1971: 130) assigns Marshall, as well as other basal-notched forms to the Grove C focus.

TABLE ROCK STEMMED: 2 specimens (Plate 2, g)

Basic description: A small to medium triangular bladed point with prominent shoulders, very larger corner-notches, a small, slightly expanding stem, and straight base.

Blade: Convex edged triangular outline with fairly thick biconvex cross-section. Both specimens have several large flakes removed from the blade edges, making them notched in appearance.

Shoulders: Strong rounded shoulders with concave outline.

Notches: Very large rounded corner notches producing a "bottle-neck" stem.

Stem: Slightly expanding with concave outline.

Base: Straight with angular corners.

Comments: Bray (1956: 127) and Perino (1968: 96) have both described Table Rock Stemmed points. They occur throughout the Ozarks and much of the Medwest (where they are sometimes called "bottle-neck" points) (Perino 1968: 96). Bray attributes them to the Middle Archaic, but Perino dates them to about 1500 B.C., or just below early Afton levels.

McHugh (1963: 45-6) states that they may persist through Delaware B times and then they decrease in size through time.

CUPP: 3 specimens (Plate 2, p-q)

Basic description: A medium to large point with narrow triangular blade, strong shoulders, elliptical corner notches, and a bulbous, convex base.

Blade: Long, narrow, triangular outline, with straight or slightly concave edges. Cross-section is medium, regular, biconvex.

Shoulders: Straight to moderately barbed with concave outline.

Notches: Broad, deep, elliptical notches, inserted at approximately 45° to medial axis.

Stem: Sharply expanding with either convex or concave outline; may have both types on same specimen.

Base: Convex, thick, with rounded corners grading directly into stem.

Comments: A variety of corner notched dart forms from the tumulus sample which were similar enough to warrant a numerical taxonomic classification. This sample of thirteen points included forms which were clearly Cupp, Etley, or Table Rock Stemmed points. However, there were also forms which appeared to possess attributes typical of two of the classes, making their classification difficult. Therefore, a cluster analysis was performed.

Fourteen measurements were made on each of the thirteen points (see Fig. 19 and Table 19). The data were standardized by column to remove the effects of size. Using the Numerical Taxonomy System (Rohlf, Kishpaugh, and Kirk 1972), with the unweighted pair group method of arithemtic (UPGMA) type of average linkage cluster analysis, the points were clustered. The resultant phenogram is presented (Fig. 25). The cophenetic correlation was .813, indicating that one dimensional space is not wholly adequate for representing all of the measured variability.

In spite of this somewhat poor cophenetic correlation, three tight clusters of points appear, accounting for eight of the points in the sample. These three clusters represent the previously defined types: Cupp, Etley, and Table Rock Stemmed. The other five points are both dissimilar to one

```
PHENOGRAM FROM MATRIX DISTAN00
  0.3250    0.2750    0.2250    0.1750    0.1250    0.0750    OTU ID.     LEVEL
              .----------------------------------------      OTHER       0.2750
              I
              I                  .---------------------      OTHER       0.1800
              I                  I
    .---------L------------------L---------------------      OTHER       0.3250
    I
    I                 .--------------------------------      OTHER       0.2350
    I                 I
    I                 I              .-----------------      OTHER       0.1600
    I                 I              I
    I                 I              I          .------      TABLE       0.1050
    I                 I              I          I
    I                 I              I.---------L------      TABLE       0.1550
    I                 I              II
    I                 I              II       .--------      CUPP        0.1150
    I                 I              II       I
    I                 I              II       I     .--      CUPP        0.0850
    I                 I              II       I     I
    I                 I            .-LL-------L-----L--      CUPP        0.1700
    I                 I            I
    I                 I            I                 .-      ETLEY       0.0800
    I                 I            I                 I
    I                 I            I             .---L-      ETLEY       0.1000
    I                 I            I             I
   ----------------------------------------------------      ETLEY
  0.3250    0.2750    0.2250    0.1750    0.1250    0.0750    OTU ID.     LEVEL

         HAS BEEN STORED.

**** ELAPSED TIME IN THIS STEP IS     0.0062 MINUTES.  TOTAL ELAPSED SYSTEM TIME IS
```

Figure 25. Cluster analysis of Cupp-like points.

another, and dissimilar to any of the three named point types. So, although these five points shared many attributes of the named types, it seems that it would be invalid to attempt to place them within any of the three classes of points to be used in the factor analysis, or to form a new class consisting of these five points.

Cupp points have been found in northeast Oklahoma, southwest Missouri, northwest Arkansas, and southeast Kansas (Perino 1971: 20). In Oklahoma, where they were defined by Baerreis and Freeman (1959: 52), Cupp points occur in the later part of the prehistoric sequence, from Grove C to Neosho Focus times (Purrington 1971: 112) and may date from A.D. 500 to A.D. 1400 (Perino 1971: 20). Perino also points out the formal similarity of Cupp points to the Gibson type of the Middle Woodland, and postulates this as the origin of the Cupp point.

Etley-like: 3 specimens (Plate 2, r)

Basic description: A long, narrow dart point, with recurving blade, moderately barbed shoulders, broad corner notches, and a short, expanding base.

Blade: Long and narrow, with a recurving edge which has been continuously retouched. Cross-section is thin and biconvex.

Shoulders: Moderately barbed with straight outline.

Notches: Broad, deep, U-shaped notches inserted at 30° to 45° to the medial axis.

Stem: Sharply expanding and short with slightly concave outline.

Base: Nearly straight with angular corners.

Comments: The three points in the present sample are similar in form to, but not exactly like the classic Etley type. The major difference is in the stem form, in that these have a sharply expanding stem, while most Etleys seem to have a more nearly straight stem. All other attributes conform closely to the Etley type. In the form of the stem and notches, the present sample somewhat resembles some of the Middle Woodland Snyders forms.

Classic Etley points are found mainly around St. Louis, Missouri and are usually found in the late pre-ceramic period, dating between about 2000 B.C. to 500 B.C. (Bell 1960: 36).

Given the resemblance of the haft element of these three points to Middle Woodland forms, they may date later than the true Etley points and may have affinities to both the Etley and Snyder forms.

It is interesting to note that while Bell asserts that Etley points have not been recovered in Oklahoma, a point is illustrated in "A Survey of Oklahoma Archaeology" (Bell and Baerreis 1951: Plate 13) which, at least in outline, is almost identical to the three points categorized here as Etley-like points. It was found in a Neosho Focus context.

AFTON: 2 specimens (Plate 2, l-o)

Basic description: A medium to large point with strongly barbed shoulders, deep, narrow notches, expanding stem, and nearly straight base. The blade often has a distinctive angle, where the edges contract to the tip.

Blade: Broad blade with straight edges which, at about 2/3 of the way up the blade, angle inward and converge at the tip. Cross-section is very thin and biconvex.

Shoulders: Strong barb, rounded at the tips.

Notches: Very deep, moderately narrow U-shaped, inserted at approximately 30° to 45° angle to the medial axis.

Stem: Moderately expanding with straight outline.

Base: Straight to subconvex with angular to rounded corners.

Comments: Although a sharply angular blade is a distinctive feature on many Afton points, neither of the two complete specimens here have the typical pentagonal blade. However, both do have blades which contract slightly about 2/3 of the way up the blade. Wood (1960: 49) has similarly classified points lacking this pentagonal blade (but possessing thin blades and certain characteristics of the notch) as Afton points.

Afton points occur throughout the western Ozark Highland. They are found in great numbers only in ceremonial contexts. Survey and excavation in the Truman Reservoir area since 1960 has shown that although the more carefully thinned, angular bladed Afton points do occur most frequently in the burial tumuli (particularly HI135, Holbert Bridge Mound [Wood 1961]), points of the same general form do occur in open and

shelter sites with some frequency (Roper, personal communication). In southwest Missouri and Oklahoma (Purrington 1971: 132) Afton points appear stratigraphically in preceramic contexts.

STANDLEE: 6 specimens (Plate 3, ee-ff)

Basic description: A moderately thick contracting stemmed point with a straight base.

Blade: Triangular with straight or slightly convex edges. One specimen is tapered at the tip, perhaps secondary retouch. Cross-section is moderately thick biconvex.

Shoulders: Three have well defined shoulders which are rounded, but angular. On these, the shoulder meets the stem in an obtuse, convex, angle. The other two have almost imperceptible shoulders; well rounded and grading into the stem.

Stem: Gradually tapering, with straight or sub-convex outline.

Base: Straight or concave with angular or slightly rounded corner where the base meets the stem.

Comments: These points resemble the Langtry type from Texas, described by Suhm, Krieger and Jelks (1954: 438-9). In fact, points of the form similar to that of the points in this sample, found in Oklahoma, have been classified as Langtry (Baerreis, Freeman, and Wright 1958). However, Scholtz (1967: 135-7) distinguished between the Oklahoma and Texas Langtry forms on the basis of thickness and a high frequency of convex-edged blades. Suhm and Krieger (1954: 438) also point out this regional variability. Both Scholtz and Marshall (1958: 120-1) therefore classify these Ozark "Langtry" points as Standlee.

Purrington (1971: 122) discusses the origins of the Standlee and Gary contracting stemmed forms and suggests that the two may have originated independently. He states that the Standlee points may have been a modified, later form of the early Hidden Valley and Searcy forms from the Ozarks, although there is an unexplainable temporal gap bebetween the forms. The independence of Gary and Standlee seems to be supported from Truman Reservoir survey data, where they tend to occur in separate sites although they do co-occur (Roper, personal communication).

In Oklahoma, Standlee tend to appear earlier than the Gary points (Purrington 1971: 122) and may date to 2000 years

ago (Bell 1958: 38). In southwest Missouri, they occur in Late Archaic and Woodland contexts.

GARY: 8 specimens (Plate 3, kk-ll)

Basic description: A triangular or ovate bladed point with a contracting stem which tapers to either a rounded or nearly pointed base.

Blade: Triangular or ovate with either straight or convex edges. Cross-section is thick, irregular biconvex in cross-section, except on one specimen which is very thin with a symmetrical biconvex cross-section.

Shoulders: Well defined, straight with rounded corners, joining the stem in a slightly rounded obtuse angle.

Stem: Varies from slightly to sharply contracting with straight edges.

Base: Rounded to almost pointed. Base grades smoothly into stem, with corners almost imperceptible.

Comments: Gary points were originally named by Newell and Krieger (1949: 164-165) from specimens in Texas. Four of the specimens in the present sample are typical of the type description. The fifth specimen, however, is somewhat different in form, although some might still lump it with Gary points. Baerreis (1953) has made a distinction between Gary and Waubesa points. This fifth specimen, although categorized here as a Gary, is typical of the Waubesa points. It is thinner, broader, larger, and better flaked than the other four specimens. It is similar in form to Dickson (Perino 1968: 18) and Adena (Bell 1958: 4) points. Both the Gary and Waubesa types are widespread throughout the Midwestern United States.

It is important to keep in mind the distinction between Waubesa and Gary in interpreting the following factor analysis, as each may be representative of different influences. Purrington (1971: 119) posits that the appearance of Gary points in the Ozarks may be due to southwestern influence. The type appears in both Archaic and later contexts. On the other hand, Waubesa points are typical of Middle Woodland Hopewell and continue into Late Woodland contexts (Perino 1971: 98).

Snyders Group: 7 specimens

The Snyders group includes points from stylistically distinct and separable classes, but which have been shown to be functionally similar. Such functional similarity has been determined by White (1971) on the basis of specimens from Illinois. Each sub-type will be described separately but will be lumped into one class for subsequent analysis.

A. WEBER (OR LANDER): 3 specimens (Plate 2, e)

Basic description: A large, broad bladed point with broad, deep corner notches and a subconvex base.

Blade: Broad with excurvate edges and a moderately thin biconvex cross-section.

Shoulders: Moderately barbed with concave outline.

Notches: Broad and fairly deep with elliptical outline, inserted at approximately 45° to medial axis.

Stem: Sharply expanding with concave outline.

Base: Subconvex with pointed corners.

B. NORTON (MARCOS C): 2 specimens (Plate 2, c)

Basic description: A medium point with broad ovate blade, strongly barbed shoulders and deep U-shaped notches.

Blade: Broad with excurvate edges and a thin biconvex cross-section.

Shoulders: Very strong, but rounded barbs and a sub-concave outline.

Notches: Deep, narrow, and U-shaped.

Stem: Sharply expanding with irregular concave outline.

Base: Subconvex with rounded corners.

C. SNYDERS (AFFINIS SNYDERS): 2 specimens (Plate 2, d)

Basic description: A medium to large, very ovate bladed point with broad deep corner notches and a convex base.

Blade: Very broad, short, blade with highly excurvate edges and a regular biconvex cross-section.

Shoulders: Very broad, pointed barbs with concave outline.

Notches: Deep, broad, rounded notches, inserted at approximately 35° to 45° angle for medial axis.

Stem: Sharply expanding with concave outline.

Base: Convex with rounded corners.

Comments: These three subgroups are lumped here into one analytical unit. Such lumping was necessitated by the rarity of these types in the tumulus assemblages. In order to achieve the frequency needed for statistical manipulation, one variable was created. The Snyders group variable seemed to be an important one, in terms of identifying and interpreting the types of cultural interaction of southwest Missouri populations with peoples outside the area. So, the importance of using the variable, combined with Montet-White's (1965) determination that all three sub-types are functionally and ultimately culturally related, justifies this lumping.

Points of this Snyders group are common in Illinois Middle Woodland components. The types are found throughout the Mississippi Valley and Ohio Valley (Bell 1958: 88) and are fairly common in Kansas City Hopewell sites (Shippee 1967). In northeast Oklahoma, points similar in form to the Norton Corner-Notched have been classified as Marcos C, and Weber points are classified as Lander Corner-Notched (Purrington 1971: 106 and 149). Stratigraphically, these points from Oklahoma can be placed in a Delaware Focus context, and continue into the Spiro and Neosho foci. In Illinois, Montet-White (1965: 359) has developed a temporal sequence for the subtypes of the Snyders point tradition: Weber, Norton, Snyders, and Affinis Snyders. They have been found in Middle Woodland Havana tradition and classic Hopewell period contexts, with the Affinis variant continuing into the Late Woodland period.

Drills

Chipped stone drills from the southwest Missouri tumuli are of various forms, with several types of bits and bases occurring in different combination. Originally each was classified according to a scheme devised by Purrington (1971: 217-224) (Table 20). He found that the formal properties of both the bit and base were important criteria for cultural interpretations, with the bit probably being the most useful attribute.

Certain limitations of the technique of factor analysis necessitated a reduction of the number of variables which were to be used in this analysis. For this reason, the numerous classes of drills from the tumuli were lumped into

TABLE 20

Drills

Bit Type*	Base Type*	Tumulus	Specimen #
B	11	BE6 Md. 3	29
B	4	BE6 Md. 2	104J
B	2	BE117	25
B	?	BE6 Md. 1	108H
E	5	BE128	NWA
E	11	BE6 Md. 3	93
E	Rice S-N	BE3	3
E or G	Rice S-N	CE122	52
E	?	BE6 Md. 3	20
E	?	BE6 Md. 2	100
E	?	SR111	NW3
D	4	BE6 Md. 2	123B
D	Rice S-N	SR141	NEF
NON-F	Rice S-N	BE3	36
NON-F	?	HI209	--(2)
NON-F	?	SR135	--
NON-F	?	CE148	--
NON-F	?	PO306	--(2)
NON-F	?	DA237	--
NON-F	?	PO307	--
NON-F	?	HI18	--

TABLE 20: Continued

Drills

Bit Type*	Base Type*	Tumulus	Specimen#
NON-F	?	CE122	--
F	8	SR138	SE
F	8	CE104	33
F	7	DA225	56
F	4	DA222	116
F	Rice S-N	SR138	NEE

*After Purrington (1971: 217-224).

just two categories: F-Type Drills and other drills. These two categories were chosen for two reasons. First, all but one drill from the sample retained enough of the bit for categorization, while several were missing their bases. Second, in addition to the fact that Purrington states that the bits are the most important chronological indicators, there seems to be a bimodal distribution in the size and, therefore, probably the function of the bits, independent of the shape of either the bit or base.

The drills classified here as F-drills (after Purrington 1971: 219) have small, needle-like bits. They are extremely narrow and cross-sections are usually diamond-shaped. They are well pointed and have nearly parallel sides. The flaking is well controlled and most show continuous bifacial retouch. This drill bit type seems to have been introduced by Spiro Focus peoples and thus may indicate a Caddoan influence into southwest Missouri.

The second class of drills includes at least three of Purrington's other bit types: B, D, and E. As a class, all are significantly larger and cruder than the F-Drills. They include bits with diamond-shaped cross-sections (B), broad, biconvex cross-sections (D), and medium biconvex cross-sections (E). All of these types of bits appear to be found predominantly in a Delaware Focus context.

Other Artifacts

POTTERY VESSELS

Ceramic vessels from the southwest Missouri tumuli are assigned to seven classes, on the basis of attributes similar to those used by Carlson (1977: 169-211). Working with sherds from rock shelters in the Truman Reservoir area of southwest Missouri, and reviewing ceramic data from other published reports from the area, she developed a tentative ceramic chronology for southwest Missouri. Using a hierarchical approach, she based her chronology on three major attributes of the sherds: (1) temper; (2) surface treatment; and (3) design elements.

Carlson used three attributes for temper: limestone, clay and shell. The term limestone is used when either all (or the predominant) tempering material is limestone. In the literature, this term is often used interchangeably with the term grit temper. Limestone-tempered pottery will often also include small particles of sand, chert, or igneous rock. Clay (or grog) tempering is the term used to indicate that the tempering agent is either fired clay or fragments of broken sherds. Shell tempering is a class which includes pottery tempered predominantly with crushed shell, and includes sherds described as being hole-tempered in cases

where the shell tempering has leached out. In addition to Carlson's three temper attributes, the tumulus sample necessitates the inclusion of two other dimensions: calcite and sand. Some sherds from the tumuli are tempered with predominantly either crushed calcite or fine particles of sand.

Carlson's second attribute, surface treatment, was three dimensional, including smooth, cord roughening, and smoothed over cord-roughening. In the present analysis, this attribute will remain two dimensional (smooth and cord-marked) as it was often difficult to distinguish between smooth surfaced sherds and those on which cord marking has been smoothed over.

In the present analysis, only temper and surface treatment will be used for ceramic classification. Except for a few sherds, there are no decorative motifs on the pottery from the tumuli, so Carlson's third attribute was irrelevant. On the basis of temper and surface treatment, seven classes are represented in the tumulus sample:

(1) Shell smoothed
(2) Shell cordmarked
(3) Calcite cordmarked
(4) Grog smoothed
(5) Limestone smoothed
(6) Limestone cordmarked
(7) Sand smoothed

There are two accounts of the ceramics in the study area which can be drawn on for an indication of the spatial distribution and temporal sequence of the various pottery classes. Wood (1961) has attempted to assign ceramic classes to various complexes in the Pomme de Terre Reservoir area of the Ozark Highland. Similarly, McMillan (1968a) has suggested a ceramic sequence for the Stockton Reservoir, an area south and west of Truman Reservoir which borders the prairie regions. Differences between the two sequences may indicate that the two regions, which are physiographically different, may also have been culturally influenced by populations in different areas.

Wood has broken the Highland Aspect, the latest Woodland Pattern culture in southwest Missouri (Chapman 1948), into the "Lindley Focus," the Fristoe Burial Complex," and the "Nemo Complex." The "Lindley Focus," based on components in the Pomme de Terre River drainage, is typified by limestone-, clay-, and sand-tempered pottery, and is placed temporally between the period of earliest pottery making and the occurrence in late prehistoric times of shell-tempered pottery (Wood 1961: 91-92).

From materials characteristic of tumuli in the "Fristoe Burial Complex," Wood has proposed a ceramic sequence: sand-tempered pottery preceding shell- and limestone-tempered pottery, preceding shell- and clay-tempered pottery. He suggests that the shell- and limestone-tempered vessels are part of the Highland Aspect and that the shell-tempered vessels can be attributed to late prehistoric Mississippian influence (Wood 1961, 1967). Thus, it is apparent that even though the tumuli included within the Fristoe Burial Complex have similar trait lists, they do not represent a single temporal unit when ceramic inclusions are considered. The sherd sample from these tumuli is not large enough to enable a refined chronological sequencing of pottery types. However, the present analysis, using data from materials other than the sherds, may help to clarify this sequence.

The "Nemo Complex" is proposed to be the latest unit within the Highland Aspect. Its temporal position has been posited on the basis of both cord-marked and smoothed shell-tempered pottery.

McMillan (1968a) has proposed a somewhat more refined sequence for the Stockton area of the Ozark Highland. The sequence reflects possible Caddoan influences absent in the Pomme de Terre area, but which would be expected in the Stockton area because of its proximity to the prairies to the west. The sequence is as follows:

(1) Clay-tempered (decorated = Middle Woodland
(2) Clay-, clay-grog-, grit- and sand tempered = Late Woodland
(3) Fine grit- and bone-tempered = Caddoan
(4) Limestone- and shell-tempered = Late Woodland
(5) Dominantly shell-tempered = Mississippian (?)

Carlson (1977: 206) suggests that the pottery sequence in southwest Missouri may not be quite so clear-cut, with one type of tempering agent totally replacing another through time. She suggests that the Central Plains Pomona Focus may have had a direct effect on the ceramics of southwest Missouri. If such is the case, clay-tempered pottery may overlap with both the Late Woodland limestone-tempered wares and the Mississippian shell-tempered wares.

NATIVE COPPER

Evidence of native copper was recovered from the southwest Missouri tumuli in three forms. Direct evidence is in the form of a massive bead, measuring 22x15x15 mm. In two other tumuli, fragments of copper were found on or near the clavicles, indicating that they were possibly ear ornaments. Thin sheets of copper (.355 to .33 mm thick) had been rolled

around wooden cores 40 to 70 mm in diameter. The remnant sheets are 30 to 36 mm in length. Indirect evidence that copper had been used either before or during the period of interment is in the form of stained bone. Several tumuli contain fragments of human cancellous tissue stained from light to dark green.

There is some question whether the copper is native material or an alloy of European manufacture (Wood 1967: 114, unpub.: 129). The existence of native copper in aboriginal contexts is well documented (e.g., Streuver and Houart 1972; Hamilton, *et al.*, 1974). In sites of the Spiro Focus copper appears in forms similar to those in the southwest Missouri tumuli.

If the copper is truely native, its origin is likely from one of two sources, as have been postulated for the Spiro copper: the Great Lakes region, or the southeastern United States (Hamilton, *et al.*, 1974: 202-3). It is possible that the copper came to Missouri indirectly, through trade with either Hopewell populations or those involved in the Southern Cult (Southeastern Ceremonial Complex).

WOLF MAXILLAE

Three tumuli contain fragments of ornaments made from wolf maxillae. The most complete of these was cut from the skull, the hard palate removed, and the base ground down so that the teeth remaining are held in place by only a small strip of bone, with the roots exposed. The posterior margin of the last tooth on each side is partially ground away. The maxilla is now in two pieces, but was originally from a nearly complete arch, lacking only the molars. The artifact was originally more than 85 mm long. This particular wolf had an anomaly: a supernumerary set of smaller canines between the incisors and the normal sized canines.

Artifacts of this type occur most frequently in a Hopewellian context during the Middle Woodland period.

ANTLER CYLINDERS

Four tumuli contained fragments of deer antler cylinders. The two complete enough to measure are 130 and 138 mm in length and 18 and 22 mm in diameter. The attaching burr on all but one specimen is smoothed. The distal ends are transversely cut and rounded, with the spongy tissue hollowed out. The holes appear to be too small for these to have functioned as handles; the intended function of these artifacts is unknown. Temporal and spatial placement is also unknown.

PEBBLE MANO

Seven tumuli contained artifacts which were unmodified except by their use as grinding, or occasionally as hammering implements. These are categorized as pebble manos. Eight of these are made of sandstone (both coarse- and fine-grained) and range in size from 53x50x30 mm to 85x78x54 mm. Three others are made of chert; one has hematite rubbed on its surface.

TRADE GOODS

Five tumuli contained items of European or Colonial American manufacture. These artifacts, listed by tumulus, and briefly described below, might indicate that the aboriginal mortuary pattern in southwest Missouri persisted until 1750 or the late 1800's when these items were introduced in the Midwest (Wood 1961: 111-112). Such would be the case, only if these artifacts are not intrusive.

There is some confusion as to whether or not this is the case. Most of them occur in undisturbed areas of the tumuli. However, due to the looseness of the fill in the cairns, it is possible that the goods were offered at some point after tumulus construction and that they trickled into the lower levels of the fill. This seems somewhat unlikely since most of these trade goods were found in close proximity to burials and other grave goods (with the exception of 23BE6-2). Although the depositional context suggests that they are not intrusive, Wood (1967: 115-116) argues that their cultural context suggests that they are intrusive, for they appear in tumuli which contain what is thought to be typologically earlier material.

If we accept these trade goods as mortuary accoutrements included with the bodies at the time of burial (as depositional context suggests) we must re-evaluate our notion of temporal assignment of archeological assemblages based on certain southwest Missouri point types. If cultural persistence in the Ozarks occurred, then situations such as this will be expected. There should be cases where a given assemblage will contain typologically early (and persistent) types in association with artifacts obtained from outside the region which are typical of a later horizon.

PO301:

Two pieces of brass:

1 strip 41x5.5x.457
1 irregular fragment 16x11x.457

DA221:

(1) Three items of white metal resembling German silver Rectangular strips of metal 7 mm x 33 mm, cut from sheets and rolled into short tubes - one with small hole near one end.

(2) 13 small tubular beads 3 to 6 mm long and 2 mm diameter longitudinally, pierced by hole less than 1 mm wide - material resembles marine conch or whelk shell.

(3) 600 glass seed beads - milky white, opaque glass average 2 mm diameter and 1 to 1.5 mm long averaging 13 beads to the inch.

BE6-2:

(1) 10 pin brooches of white metal - probably silver alloy - with thin tongue for attachment; 9 are 16 mm diameter, 1 is 20 mm.

(2) Ear bob - white metal 36 mm long.

(3) Top half of brass bell with thin wire suspending loop originally 15 mm diameter.

(4) Two glass beads - faceted and blue.

(5) Hard rubber comb - not recent.

(6) Two steel buttons.

BE6-3:

(1) Four pin brooches.

(2) Two metal bangles or "tinklers" roughly cut from brass and rolled into slightly tapered cylinders 29 and 31 mm.

(3) Bangle (?) of iron or steel.

(4) Small piece of fabric; some cords wrapped with brassy-appearing metal - not recent.

BE128:

Three beads - rolled short strips of brass 7 to 10 mm wide and 2 to 3 mm thick into ornaments 9 to 11 mm diameter with irregular hole 4 to 5 mm wide.

Analyzed by x-ray by Dr. Edward Olsen, Curator of Mineralogy at Chicago Natural History Museum (personal communication with Wood 13 March 1964) — "the zinc content was much too high to be a mere impurity in native copper. They are too "dirty," or contain too many elements, to be modern alloys, and he feels that they are manufactured alloys of probably European or Colonial American origin" (Wood 1967: 62).

SHAPED MANOS

Ten tumuli contained manos whose shape had been intentionally modified prior to their use as tools. All (with the exception of the 'cottonrock" item from 23PO165) were made of sandstone. The various shapes of these manos are described below.

HE139 (n=1)

Fine-grained sandstone - made by pecking and grinding a river pebble - some unmodified stream rolled surface remains. Center of both faces bears a small pecked depression, 94x76x44 mm.

CE148 (n=3)

Two fine-grained sandstone - oval with subrectangular cross and longitudinal section with both faces lightly pitted, 109x76x38 mm.

One fine-grained sandstone - elongated egg-shaped with nearly circular cross-section and elliptical longitudinal section, 176x83x75 mm.

CE152 (n=1)

Fine-grained buff sandstone - roughly oval, 120x64x60 mm.

DA222 (n=1)

Sandstone - ovoid in outline, subrectangular cross-section - carefully finished; both ends used as hammers, 117x73x39 mm.

DA225 (n=1)

Fine-grained sandstone - oval in outline - 2 broad faces ground flat - edges evenly shaped so cross-section is rectangular, 125 (est.) x70x39 mm.

PO300 (n=1)

Medium-grained sandstone - subrectangular in outline and in cross and longitudinal section.

DA237 (n=1)

Fine-grained sandstone - oval in outline with subrectangular cross-section; both faces smoothed, edges battered, 110x70x36 mm.

DA219 (n=3)

Three coarse-grained gray or brown sandstone - from oval pebbles. Two flat sides and edges trimmed by pecking. Width 63 to 83 mm, thickness 41 to 60 mm.

PO165 (n=5)

Worked pieces of cottonrock - ground smooth on one or both sides.

DA221 (n=1)

Dark brown coarse-grained sandstone - nearly rectangular in cross and longitudinal section with heavily rounded corners - two faces pitted but only one surface ground smooth, 117x95x83 mm.

MOLLUSK SHELL BEADS

Nine tumuli contained beads fashioned from fresh water mollusk shell. All were flat disk beads with a hold pierced either by conical pits drilled from both sides, or by cylindrical holes. They range in size from 7 to 14 mm in diameter and 3 to 6 mm thick, with most falling in the small end of the range. For the most part these beads are smaller and not as well made as the conch shell beads from the tumuli.

These beads may be of local manufacture, as fresh-water mussels are readily available within the streams of the area. Beads of this type are probably not spatially or temporally diagnostic.

SNAIL SHELL BEADS

Twenty-two tumuli contained beads manufactured from snail shells. These were of two types: Periwinkle and more commonly Anculosa. The Periwinkle shells all had an irregular hole in one side which could have served to suspend them. The Anculosa beads were fashioned by brinding one side flat. As both types of snails are prevalent and probably served similar functions, they were combined into one class for the present analysis.

MARINE SHELL BEADS

Thirty-two tumuli contain various kinds of beads manufactured from marine snails (conch or whelk). From conch columella, there are three types of tubular beads: circular, triangular, and rectangular in cross-section. Also from conch or whelk are barrel-shaped ornaments. The most numerous of the marine beads are the discoidal shapes with cylindrical perforations. These have a large size range, and tend to be much larger than the fresh water mollusk disk beads. In addition to these conch and whelk beads, there are a number of small beads made from the marine snail, Marginella.

The origin of the raw material for these beads, as well as the conch pendants to be discussed, is the Gulf Coast. Whether the source of the present artifacts is directly from there is not known. Marine shell is a common material for artifacts in Spiro Focus sites, as well as Hopewell Middle Woodland sites. In addition to the completed artifacts in the tumuli, there are several pieces of unmodified conch and whelk, implying that the raw material was obtained outside southwest Missouri and that at least some of the beads were manufactured locally.

BONE AWLS/PINS

Narrow bone tools with a pointed, smoothed working end were in twenty of the tumuli. These were of four basic forms, dependent upon the type of bone from which the tool was manufactured. The most numerous class was that of awls made from deer metapodials. Some of these were made with little modification to the original bone, save for splitting. Others were extremely modified by polishing or working the distal end, creating an elaborate tool. Other awls or pins were manufactured from thick long bones of large mammals. Some of these were flat, others gently taper with a circular cross-section, and still others were merely bone splinters. A third type of awl was made from the long bones of smaller mammals. The fourth, and rarest type consisted of deer ulnae, the distal ends of which had been smoothed and rounded. Most of the awls were fragmentary, making measurement impossible. Two of the more nearly complete deer metapodial awls were 156 mm and 75 mm long.

BONE BEADS

Beads made from various kinds of bone were found in ten of the tumuli. All of them are tubular and are made from either the long bones of large birds or small mammals. They are smoothed and polished on the ends, but bear no decoration or modification except for one bead from 23BE135. One end of this bead is deeply scored all around. This may be a

decoration or may have been an attempt to cut the bead. The beads are of various sizes, ranging from 8 to 38 mm long and 5 to 21 mm in diameter.

Although cylindrical bone beads are found throughout North America, they are rarely so common as they are in the present sample of tumuli, with the exception of the Plains. In this trait, a comparison may be drawn with artifacts from tumuli in eastern Kansas: the Schultz Focus (Eyman 1966: 116). In these tumuli, which probably date to the Woodland period, and are of similar structural form and burial mode to those in southwest Missouri, bone beads were the second most numerous artifact form. Of the 1,353 bone beads, 76 per cent were undecorated, cylindrical forms.

TURTLE SHELL

Seven tumuli contained artifacts made from turtle shell, or fragments of turtle shell which had been modified. Two tumuli (23DA222 and 23DA226) had several pieces of box turtle carapace with the plastron removed. The thick inner margins were then ground smooth, so the thickness of the shell was nearly uniform. The function of these artifacts is unknown. Perhaps some represent bowls, but some fragments are cut along points near the center of the carapace, as if they had been shaped in forms other than bowls.

From 23CE150 came the carapace of a small Ornate box turtle (*Terrapene ornata*), measuring 110 mm long, 93 mm wide, and 45 mm deep. The edges of this bowl were ground, forming a smooth rim; the interior was similarly ground. This bowl was found open side up, with twenty-six large *Anculosa* beads resting inside. The bowl with its bead inclusions is reminiscent of a rattle. However, a comparison of this artifact with Winters' summary (1969: 74-79) and description of rattles in both historic and prehistoric contexts makes such an identification tenuous.

In addition to these three bowl-like artifacts, several tumuli contained fragments of turtle shell which had margins and interiors ground smooth. A functional assessment based on these fragments is impossible.

OTHER BONE TOOLS

In addition to the bone beads, awls or pins, turtle shell, and antler cylinders, there were several other forms of artifacts manufactured from bone. These have been placed into a single class. Each form is described briefly.

Butted spatulae: These flat-shafted bone tools occurred in several tumuli but were most numerous in CE150. The most

nearly complete specimen is from that mound. It is made from the long bone from a mammal, larger than a deer. The shaft, 202 mm long, has a thin oval cross-section and a blunt tip. The butt retains portions of an articular surface and is worked into a subrectangular platform. The specimen is highly polished, with most of the cancellous tissue removed.

Embellished spatulae: An occasional specimen, similar in general form to the tools just described, has been decorated. One from CE150 has cross-hatching on the butt end. There are two specimens from DA222 which have a series of pits drilled into the convex surface.

Bone nails: These artifacts have circular disk-like heads, approximately 17 mm in diameter, and tapering tips. Their shafts, approximately 170 mm in length, with circular cross-sections, distinguish them from the spatulae and bone awls.

Metapodial wrench: A specimen from CE150 is classified as a metapodial shaft wrench. Made of deer bone, this artifact has had both ends reduced and a beveled perforation near the distal end.

Ulna flakers: These tools are made of deer ulnae whose distal ends have been blunted. The proximal ends of the bones are usually unmodified.

HEMATITE

Eighteen of the tumuli contained at least one fragment of hematite. For the most part these had at least one face which was rubbed smooth, presumably for obtaining pigment. (One tumulus, 23BE6-2, had a sandstone abrader with hematite pigment adhering.) Several of these same tumuli also contained pieces of yellow ochre, presumably used for the same purpose. Most pieces were less than 30 mm in diameter, although one from 23BE6-1 was 54x38x11 mm and one from 23BE118 measured 60x46x36 mm. Additionally, some tumuli contained unmodified and/or fire cracked pieces of hematite. Although classified elsewhere for the present analysis, it should be noted that the celt from 23HI209 was made from hematite.

Although the use of hematite is not diagnostic of any one cultural unit or time period, Middle Woodland sites are particularly well known for artifacts made from this material. Bell (1947: 182) has noted, in attempting to identify sources of trade materials at the Spiro Mound in Oklahoma, that one of the best known sources of this material is near Leslie, Missouri. Given the prevalence of hematite in stream

deposits (see Ray 1980) and its frequent occurrence in sites of several time periods (House 1977), the presence of hematite cannot be used to infer temporal placement or cultural contacts.

GROUND STONE AND POTTERY PIPES

Ceramic pipes were recovered from six of the tumuli. Two of these same tumuli (as well as four others) contained fragments of pipes which had been manufactured from stone. Pipes made from either material are too widespread spatially and temporally to be of much use as diagnostic artifacts. They are prevalent throughout the Eastern Woodlands and although they seem to be ubiquitous during the Middle Woodland/ Hopewell and Spiro periods, are not confined to them. Below is a list, by tumulus, of the ground stone and ceramic pipes. Only a brief description is offered of each, as the fragmentary nature of most specimens makes full description of the original forms impossible.

A. Stone

HI209 — limestone elbow, barrel-shaped bowl, stubby cigar-shaped stem

CE148

(1) light buff limestone stem
(2) siltstone bowl of cylindrical pipe
(3) limestone plain cylindrical bowl and tubular stem
(4) limestone complex bowl with notched lip

DA222

(1) siltstone - elbow
(2) siltstone - perhaps same form as other - perhaps two pipes

DA225

(1) black shale - elbow - cylindrical bowl with flat lip
(2) grey siltstone - elbow - cylindrical bowl - stem oval in cross-section

DA226

(1) fine-grained sandstone - narrow keel on anterior of bowl
(2) siltstone - rim of bowl below which is an incised line

DA219 – limestone - elbow with very short subrectangular stem and tall cylindrical bowl

B. Pottery

CE123 – lip decorated with incised lines at right angles across lip

DA225 – limestone tempered with broad, flat-lipped bowl

DA226 – limestone tempered - elbow with cylindrical bowl and stem of equal length-rim of bowl and stem slightly flared.

DA246

(1) limestone tempered - lip rounded
(2) limestone tempered - bowl expands toward flat lip - incised line encircles lip along its midline, with shorter lines extending from inner to outer edge of bowl

PO306 – finely crushed shell - large pipe - thin walled bowl - cylindrical or truncated cone with nearly flat lip with closely spaced transverse tool impressions and three lightly incised lines encircling bowl just below lip - broad, cylindrical stem - probably elbow

PO307 – limestone and calcite tempered effigy pipe - tubular bowl with beak of bird of prey (owl?) on front with eyes incised - stem same diameter as bowl but not simple cylinder - grass stem produced hole

CELTS

Fragments of celts were recovered from six tumuli. They were of three different types of material. Greenstone celts were found in 23CE154, 23DA225, 23DA226, with two from 23CE152. The only complete specimen was well ground, with a broad convex cutting edge and a small, battered poll, and measuring 136x68x38 mm. A small (45x51x7 mm) hematite celt was recovered from 23HI209. From 23CE123 came a dark grey groundstone celt. Celts seem to be ubiquitous during most time periods in most regions.

CONCH PENDANTS

Ten conch shell pendants were recovered from eight tumuli. Each is briefly described below. The pendants were rectangular in outline, except for the circular, engraved piece from

BE6-2. The latter specimen depicting a jaguar or panther, is reminiscent of gorgets and motifs found throughout the southeastern United States during the Mississippian period (Chapman and Chapman 1964: 73; Howard 1968: 54), although Wood and Griffin (Wood 1961: 106) have suggested that the design is Hopewellian in style. Neither conclusion can be readily confirmed: the presence in the tumulus of white trade goods and Mississippian period artifacts argues for the later temporal placement, while the mammiform object found associated with it argues for the earlier placement. The rectangular gorgets seem to be diagnostic of neither temporal nor spatial placement.

BE6-2 — Engraved conch gorget 104 mm wide and 98 mm high, with one large central hole and two smaller performations near one edge.

Jaguar - exaggerated body length, but otherwise realistic.

Three-lobed "speech symbol" (see Wood, 1961: cover)

DA201 — Rectangular gorget 74x70x6 mm - conch. Both faces and edges are smoothed and a hole 3-4 mm diameter drilled through long dimension and another hole near the center of the gorget connects the other holes. Diameter suggests the use of a reed for drilling.

CE198 — Two gorgets of conch or whelk - size and shape indeterminate.

CE152 — Rectangular conch or whelk, 47x27x2 mm, with gently rounded corners. Cord or thong used to suspend it has worn grooves in one side of the holes which pierce the pendant.

CE154 — Gorget, conch or whelk - fragmentary, but enough remaining to tell that it was identical in manufacture technique to that from DA201.

DA222 - Small piece of gorget, probably rectangular in outline, with hole pierced near one edge.

DA226 — Three small fragments of conch with straight edges, suggesting it was rectangular gorget.

PO307 — Two small conch gorgets - rectangular and drilled similarly 50x32x10 mm and 29x13x5 mm. Pierced along long axis with cylindrical hole 3 mm in diameter from each end, these holes intersect at an angle near the center of the piece.

Other Variables

CORN

Carbonized corn kernels and cob fragments were recovered from fourteen tumuli. Except for HI208, which was in the Pomme de Terre Reservoir area, all tumuli with evidence of corn were in the Stockton Reservoir area. Some of this maize (Zea mays) was examined by Cutler and Blake (1973). These samples, as well as maize from eight other tumuli, and other nuts and seeds were examined by King (1978: see our Appendix D).

From samples throughout the Midwest, Cutler and Blake (1969) and Yarnell (1964) generalize that after A.D. 1000-2000 maize was primarily 8-rowed, strongly paired, and somewhat crescent shaped. Earlier corn, derived from the Southwest was generally 12 to 14-rowed. Due to the variability both in their samples and in the tumulus samples, such general statements do not lend themselves to valid conclusions about the source or temporal placement of the tumulus maize.

The present analysis is based only on the presence or absence of maize; not its quantity. The presence of corn in a tumulus only suggests that the tumulus builders supplemented their diet with corn. It is not unlikely that the populations in southwest Missouri had the knowledge and technology necessary for cultivation of maize, even in the Woodland period. There is evidence that other cultigens were used in the area as early as the Middle Archaic period (Chomko 1976). The extent of the dependence on such cultigens is being tested with skeletal data (Brock 1980).

TUMULUS FORM AND STRUCTURE

Form

Those tumuli which are constructed almost entirely of rock are classified as cairns. When earth fill is also a major component of the tumulus, it has been classified as a mound. The differentiation between the two forms was sometimes difficult. The designation of the original excavator was used in all cases.

Structure

Three classes of structure have been used in the present study: (1) tumuli which had no internal features, (2) tumuli which had subfloor pits of any form, and (3) tumuli which had any form of rock enclosure (rings or chambers enclosing skeletal materials or not).

APPENDIX B

DISTRIBUTION OF PROJECTILE POINT TYPES

The following table is a schematic of the spatial distributions of several of the projectile point types which occur in the tumuli. This representation of geographical range is used in the analysis as an aid to the determination of cultural associations that the tumulus builders may have had with populations in surrounding areas.

Table 21 was generated by comparing artifact types from the southwest Missouri tumuli with assemblages from sites in other areas of Missouri, as well as from sites in Kansas, Iowa, Nebraska, and the Northern Great Plains. An artifact was considered present when descriptions, figures, or plates in site reports compared favorably with the southwest Missouri assemblages.

TABLE 21

Spatial Distribution of Projectile Point Forms

	Study Area		Southwest		East		Northeast		North			Kansas									Iowa	Nebraska			N.Great Plains
	Rodgers Shelter (Kay 1977)	Truman Survey (Roper 1977)	N.E. Oklahoma (Purrington 1971)	Table Rock Reservoir (Marshall 1958)	Gasconade River (McMillan 1965b)	Lower Osage River (Klippel 1965)	Southern Illinois (Montet-White 1968)	Central Illinois (Morse 1963)	Missouri River (Denny 1964)	Big Bend, Missouri (McKinney 1954)	Western Missouri (Chapman 1959)	Kansas City (Wedel 1943)	Fishing River (Martin 1976)	Kansas City (Shippee 1967)	Eastern Kansas (Wedel 1959)	Pomona Reservoir (Wilmeth 1970)	Eastern Kansas (Eyman 1966)	Milford Reservoir (Witty 1963)	Elk City Reservoir (Marshall 1972)	Wilson Reservoir (Witty 1962)	Northwest Iowa (Anderson 1973)	Nebraska (Kivett 1952)	Eastern Nebraska (Hill & Cooper 1939)	Central Nebraska (Hill & Kivett 1941)	Sonota Complex (Neuman 1975)
Rice Side Notched	X	X	X	X	X	X	X	X	X	X	X		X	X											
Cooper-like		X	X	X		X	X	X	X	X		X	X	X	X		X	X	X						X
Standlee	X	X	X	X	X	X	X		X	X	X		X	X					X						
Gary	X	X	X	X		X	X		X		X	X	X	X	X		X	X	X						
Scallorn	X	X	X	X	X	X			X	X	X		X	X			X		X	X		X		X	
Reed	X	X	X			X				X			X	X	X	X		X		X					
Washita			X										X		X				X	X	X				
Huffaker	X		X						X				X		X	X	X		X	X	X		X		
Harrell	X											X	X		X				X		X	X	X		
Keota			X																		X				
Haskell			X	X																					
Fresno	X	X	X	X	X				X	X	X	X	X	X	X	X			X	X	X		X		
Crisp Ovate	X	X	X		X	X			X				X	X	X	X			X	X	X	X	X	X	
White R. Ellip.	X		X	X	X							X	X		X							X	X		
Guffy-like	X	X	X	X							X			X					X						
Marshall	X	X	X				X				X								X						
Cupp	X	X	X		X																				
Table Rock Stemmed	X	X	X	X																					
Snyders		X	X	X		X	X		X	X			X	X				X	X						
Etley-like			X						X					X											
McConkey	X	X	X								X		X						X						
Afton	X	X	X			X					X			X					X						
Delaware	X		X	X					X		X						X	X	X						
Rice S-N Variant						X																			

Key for TABLE 21

Reference	Site or Complex	Temporal Affiliation	Area	Environment
Roper, 1977	Surface-open air sites	All periods	Truman Reservoir	Ozarks
Kay, 1977	Rodgers Shelter	All periods	Truman Reservoir	Ozarks
Purrington, 1971	Habitation sites	All periods	N.E. Oklahoma	Ozarks
McMillan, 1965	Gasconade sites	All periods	S. Central Missouri	Ozarks
Marshall, 1958	Table Rock sites	All periods	Southwest Missouri	Ozarks
Chapman, 1959	Osage	Proto-historic	Western Missouri	Ozarks/prairie
Shippee, 1967	K.C. Hopewell	Hopewell/L. Woodland	Kansas City	Missouri River
Eyman, 1966	Schultz Focus	Middle to Late Woodland	East Kansas	Riverine
Neuman, 1975	Sonota Complex - habitations and mounds	Woodland	N. Great Plains	Missouri River
Montet-White, 1968	Snyders Site	Woodland	Illinois	Riverine
Morse, 1963	Steuben Village and mounds	Late Woodland	Central Illinois	Illinois River
Anderson, 1973	Brewster Site	Mill Creek	Northwest Iowa	Riverine
Witty 1962	Hell Creek Valley sites	Central Plains and Woodland	Wilson Reservoir, Central Kansas	Smoky Hills; plains
Witty, 1963	Streeter and Woods sites	Woodland	Milford Reservoir, Northeast Kansas	N.W. Flint Hills
Wilmeth, 1970	Masenthin graves and Hart	Pomona Focus	Pomona Reservoir, Eastern Kansas	Osage Cuestas
Wedel, 1943	Woodland sites	Woodland	Kansas City	Missouri River
Kivett, 1952	Woodland sites	Woodland	Nebraska	Plains and riverine
Hill & Cooper, 1939	Nebraska culture	Woodland	Eastern Nebraska	Missouri River
Hill & Kivett, 1941	Vy-1	Woodland	Central Nebraska	Prairie
Marshall, 1972	Elk City Res. sites	Woodland	Southeast Kansas	Osage Cuestas
McKinney, 1954	Hopewell	Middle Woodland	Central Missouri	Missouri River
Martin, 1976	Fishing River sites	All periods	Kansas City	Missouri River
Klippel, 1965	Lower Osage River sites	All periods	Central Missouri	Osage River
Denny, 1964	Boone Focus	Woodland/Mississippian	Central Missouri	Missouri River

APPENDIX C

CHERT UTILIZATION

Data on the types of chert represented in the tumulus assemblages were collected for their bearing on questions about two types of chert utilization: procurement of cherts indigenous to the area and of exotic materials and goods. Other types of chert data were collected during investigations in the Truman Reservoir area, which will allow comparisons between chert types actually used prehistorically and those which were locally available.

The first phase of data collection was done to enable identification of different chert types which might be found archeologically. A comparative collection was assembled consisting mainly of cherts from the Truman Reservoir area, but also with samples of cherts from the Stockton Reservoir area and from regions to the east and west of the Truman Reservoir, the Kansas City area, and northeast Oklahoma. This comparative collection allowed the general identification of the source of most of the cherts in the archeological assemblages. It also allowed determinations that certain cherts were obtained from outside the regions represented by the comparative collection, i.e., exotic cherts, (see Reagan 1980, for more detail).

The second phase of the chert study involved modeling the availability of chert types within the Truman Reservoir (Ray 1980). This involved detailed mapping of areas (1 km radius) around eleven archeological sites (Table 22). By accounting for such variables as height of outcrop, chert quality, and stream transported cherts, a profile of availability was developed for each site. This profile of availability is expressed as percentages of the existing chert types (Table 22).

The portable tools from the tumuli were next examined microscopically and identified to chert types by Robert Skrivan, on the basis of fossil inclusions (Table 23). These data are summarized in Table 24.

These data will be useful for ongoing studies of patterns of chert procurement. A first step towards such an analysis is presented here. It might be expected that populations would use chert types in the proportion that they were readily available. To test this proposition, seventeen chi-square goodness-of-fit tests were performed to compare percentages of chert occurring in various tumuli to those which occurred naturally in the chert catchments closest to

TABLE 22

Chert Availability

Site at Center of Chert Collection Area	Percent of Chert Available*				
	Mo	Mk	Ojc	Mn	Or
23BE676	15	10	75	0	0
23BE660	10	10	80	0	0
23BE681	5	10	85	0	0
23SR189	20	60	20	0	0
23BE337	17	8	75	0	0
23SR504/675	5	20	75	0	0
23HI297	6.5	3	90	0	0.5
23BE125	10	10	80	0	0
23HE9	100	0	0	0	0
23SR400	49	29	21	1	0
23SR653	45	33	22	0	0

*Mo=Burlington
Mk=Chouteau
Ojc=Jefferson City
Mn=Warsaw
Or=Roubidoux

TABLE 23

Chert Identification of Tumulus Tools

	Scallorn						Rice Side Notched								Cooper						Huffaker				Harrell				Late Woodland			Haskell		Afton						Reed			
	Mo	Ojc	Mk	Ind M	Ind O	Ex	Mo	Ojc	Mk	Or	Mn	Og	Ex	Ind M	Mo	Ojc	Mk	Mn	Ind M	Ind O	Mo	Ojc	Mk	Ind M	Mo	Ojc	Ind M	Mk	Mo	Ojc	Mk	Ojc	Mk	Mo	Ojc	Mk	Ex	Mn	Ind M	Ojc	Mk	Mn	Ex
BE6-1	6	3	1	1	-	-	2	6	4	-	-	-	-	2	1	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE6-2	32	36	17	-	5	1	27	18	1	1	1	-	-	4	8	8	5	2	-	1	-	3	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-
BE6-3	12	7	5	3	-	-	8	5	1	-	-	1	-	-	-	10	1	-	-	-	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
BE6-4	-	1	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE117	2	2	-	-	2	1	-	1	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE3	2	-	1	-	-	-	5	9	1	-	-	-	1	1	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
BE128	2	1	2	1	-	-	2	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE118	1	-	4	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE135	1	1	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE136	-	-	-	-	-	-	1	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE104	8	12	8	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE122	-	-	-	-	-	-	14	-	4	-	1	-	-	1	21	-	11	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE123	3	1	-	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	2	6	1	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
CE190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA201	1	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE139	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30A	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30C	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI149	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR111	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
SR135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR141	-	-	-	-	-	-	3	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE148	1	5	7	-	-	-	2	1	4	-	2	-	-	1	5	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE150	5	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	-
CE152	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE154	4	13	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA222	1	4	4	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA225	-	3	5	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-

TABLE 23: Continued

Chert Identification of Tumulus Tools

	Scallorn						Rice Side Notched								Cooper					
	Mo	Ojc	Mk	Ind M	Ind O	Ex	Mo	Ojc	Mk	Or	Mm	Og	Ex	Ind M	Mo	Ojc	Mk	Mm	Ind M	Ind O
DA226	3	1	3	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
DA246	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
PO306	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO300	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-
PO301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO307	4	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI18	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
HI208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO304	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA250	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
DA216	-	1	-	-	-	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-
DA237	2	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA219	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
DA221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR138	2	5	11	1	1	-	1	3	2	-	2	-	-	-	-	-	-	-	-	-
HE150	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	Huffaker				Harrell				Late Woodland			Haskell		Afton						Reed			
	Mo	Ojc	Mk	Ind M	Mo	Ojc	Ind M	Mk	Mo	Ojc	Mk	Ojc	Mk	Mo	Ojc	Mk	Ex	Mm	Ind M	Ojc	Mk	Mm	Ex
DA226	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA246	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-
PO300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO301	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO307	3	1	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
HI18	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
HI208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO304	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
DA250	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-
DA216	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA237	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA219	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR138	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
HE150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-	-	-	6	16	4	1	1	1	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 23; Continued

Chert Identification of Tumulus Tools

	Fresno					RSN Variant		Crisp				Drills				
	Mo	Ojc	Mk	Ind M	Ex	Ojc	Ex	Mo	Ojc	Mk	Ex	Mo	Ojc	Mk	Mn	Og
DA226	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
DA246	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO306	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
PO300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO307	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI18	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO304	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA216	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA237	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA219	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA221	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
SR138	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
HE150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	F-Drills				Unclassified Arrows						Other Darts						
	Mo	Ojc	Mk	Ind M	Mo	Ojc	Mk	Ind M	Ind O	Ex	Mo	Ojc	Mk	Ind M	Ind O	Mn	Ex
DA226	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
DA246	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
PO306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
PO301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO307	-	-	-	-	1	1	1	-	-	-	1	-	-	-	-	-	-
HI18	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
HI208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO304	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
DA250	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
DA216	-	-	-	-	3	-	-	-	-	1*	-	-	-	-	-	-	-
DA237	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-
DA219	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA221	-	-	-	-	1	-	-	-	-	1	2	-	-	-	-	-	-
SR138	1	1	-	-	-	2	5	-	-	-	1	-	1	-	-	-	-
HE150	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

	Knives								White R. Elliptical		
	Mo	Ojc	Mk	Ind M	Ind O	Mn	Og	Ex	Mo	Ojc	Mk
DA226	-	1	-	-	-	-	-	-	-	1	-
DA246	-	-	-	-	-	-	-	-	-	-	-
PO306	-	-	-	-	-	-	-	-	-	-	-
PO300	-	-	-	-	-	-	-	-	-	-	-
PO301	-	-	-	-	-	-	-	-	-	-	-
PO307	1	-	-	-	-	-	-	-	-	-	-
HI18	-	-	-	-	-	-	-	-	-	-	-
HI208	-	-	-	-	-	-	-	-	-	-	-
PO304	-	-	-	-	-	-	-	-	-	-	-
DA250	-	-	-	-	-	-	-	-	-	1	-
DA216	-	-	-	-	-	-	-	-	-	-	-
DA237	-	-	-	-	-	-	-	-	-	-	-
DA219	-	-	-	-	-	-	-	-	-	-	-
DA221	-	-	-	-	-	-	-	-	-	-	-
SR138	-	1	2	1	-	-	-	-	-	-	-
HE150	-	-	-	-	-	-	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-

*Limestone

Mo - Burlington
Ojc - Jefferson City
Mk - Chouteau
Ind M - Indeterminant Mississippian
Ind O - Indeterminant Ordovician
Mn - Warsaw
Og - Gasconade
Ex - Exotic
Or - Roubidoux

TABLE 23

Chert Identification of Tumulus Tools

	Guffy				Cupp and Cupp-like				Snyders Group			Gary			Standlee		Marshall		Washita		Table Rock Stone		Delaware		Keota		Etley-like		McConkey		
	Mo	Ojc	Mk	Ind M	Mo	Ojc	Mk	Ind M	Mo	Ojc	Mn	Ojc	Mk	Mn	Ojc	Ex	Ojc	Mk	Mo	Ojc	Mo	Ojc	Mo	Mk	Mo	Mk	Mo	Ojc	Mo	Ojc	Mk
BE6-1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE6-2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE6-3	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
BE6-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
BE112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE3	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE136	-	1	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE104	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE122	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CE123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CE190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-
CE198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE139	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR111	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE148	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE152	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE154	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA222	-	-	-	-	1	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
DA225	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1	2	-	-	-

TABLE 23

Chert Identification of Tumulus Tools

	Fresno					RSN Variant		Crisp				Drills					F-Drills			
	Mo	Ojc	Mk	Ind M	Ex	Ojc	Ex	Mo	Ojc	Mk	Ex	Mo	Ojc	Mk	Mm	Og	Mo	Ojc	Mk	Ind M
BE6-1	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	1	-	-	-	-
BE6-2	-	2	-	-	-	2	-	-	-	-	-	-	2	-	-	-	-	1	-	-
BE6-3	1	2	-	1	-	1	-	-	-	-	-	2	1	-	-	-	-	-	-	-
BE6-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE117	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
BE3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
BE128	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
BE118	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE135	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE136	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CE122	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
CE123	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CE190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE139	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30C	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR111	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
SR135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR141	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
CE148	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE152	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CE154	-	1	-	-	-	-	-	-	3	4	2	-	-	-	-	-	-	-	-	-
DA222	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
DA225	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-

	Unclassified Arrows						Other Darts							Knives								White R. Elliptical		
	Mo	Ojc	Mk	Ind M	Ind O	Ex	Mo	Ojc	Mk	Ind M	Ind O	Mm	Ex	Mo	Ojc	Mk	Ind M	Ind O	Mm	Og	Ex	Mo	Ojc	Mk
BE6-1	-	1	-	-	-	-	-	2	1	-	-	1	-	1	1	-	-	-	-	-	-	-	1	-
BE6-2	7	6	2	-	-	-	5	6	-	1	1	1	-	2	17	2	1	-	1	-	-	-	1	-
BE6-3	5	6	4	1	-	1	1	8	2	-	-	-	-	-	1	-	-	-	-	-	-	-	1	1
BE6-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE117	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2	-	1	1	-	-	-	-	-	-
BE3	-	-	1	-	-	-	1	3	1	-	-	-	-	-	4	1	3	1	-	-	2	-	-	-
BE128	-	2	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
BE118	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
BE135	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE136	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE104	1	4	1	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE122	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE123	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CE190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA201	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE139	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI30A	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
HI30C	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
HI149	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
HI209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR141	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-
CE148	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
CE150	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE152	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE154	-	2	2	1	-	-	1	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA222	-	-	2	1	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-
DA225	-	3	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-

TABLE 23: Continued

Chert Identification of Tumulus Tools

	Guffy				Cupp and Cupp like				Snyders Group			Gary			Standlee		Marshall		Washita		Table Rock Stone		Delaware		Keota		Etley-like		McConkey		
	Mo	Ojc	Mk	Ind M	Mo	Ojc	Mk	Ind M	Mo	Ojc	Mm	Ojc	Mk	Mm	Ojc	Ex	Ojc	Mk	Mo	Ojc	Mo	Ojc	Mo	Mk	Mo	Mk	Mo	Ojc	Mo	Ojc	Mk
DA226	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
DA246	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO306	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
PO300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
PO301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO307	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO304	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA250	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA216	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
DA237	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
DA219	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
SR138	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 24

Chert Types by Tumulus

Site	Mo	Ojc	Mk	Ind.M	Ind.O	Mn	Og	Ex	Or	Total	Total non-local	% non-local
BE6-1	10	24	7	3	0	1	1	1	0	47	6	12.8
BE6-2	81	106	28	6	7	5	0	1	1	235	19	8.1
BE6-3	31	45	16	5	0	0	1	2	0	100	8	8.0
BE6-4	0	3	1	0	0	0	0	0	0	4	0	0.0
BE112	0	0	0	0	0	0	0	0	0	0	0	--
BE117	3	7	4	1	3	2	0	1	0	21	7	33.3
BE3	12	17	6	4	1	3	0	3	0	46	11	23.9
BE128	4	8	3	1	0	0	0	0	0	16	1	6.3
BE118	3	3	4	1	0	0	0	0	0	1	1	100.0
BE135	3	3	2	0	0	0	0	0	0	8	0	0.0
BE136	2	3	1	2	0	0	0	1	0	9	3	33.3
CE104	13	17	10	3	0	0	0	0	0	43	3	7.0
CE122	41	0	17	2	0	3	0	0	0	63	2	3.2
CE123	9	12	3	3	1	0	0	1	0	29	5	17.2
CE190	0	0	0	0	0	0	0	0	0	0	0	--
CE198	0	0	0	0	0	0	0	0	0	0	0	--
DA201	3	0	2	0	0	0	0	0	0	5	0	0.0
HE139	2	3	0	0	0	0	0	0	0	5	0	0.0
HI30	0	0	0	0	0	0	0	0	0	0	0	--
HI30a	1	0	0	1	0	0	0	0	0	2	1	50.0
HI30c	4	3	0	0	0	0	0	1	0	8	1	12.5
HI149	2	4	0	0	0	0	1	0	0	7	1	14.3
HI209	0	0	0	0	0	0	0	0	0	0	0	--
SR111	3	3	0	0	0	0	0	0	0	6	0	0.0
SR135	0	0	0	0	0	0	0	0	0	0	0	--
SR141	4	3	0	1	0	1	0	1	0	10	3	3.0
CE148	9	8	16	1	0	2	0	0	0	36	3	8.3
CE150	6	4	6	1	0	0	0	0	0	17	1	5.9
CE152	1	3	5	0	0	0	0	0	0	9	0	0.0
CE154	7	20	14	2	0	0	0	2	0	45	4	8.9
DA222	7	4	6	3	0	1	0	1	0	22	4	18.2
DA225	2	10	10	2	0	0	0	1	0	25	3	12.0
DA226	6	3	4	2	1	0	0	1	0	17	4	23.5
DA246	3	0	1	1	0	0	0	0	0	5	1	20.0
PO306	0	0	5	0	0	1	0	1	0	7	1	14.3
PO300	1	0	3	0	0	0	0	2	0	6	2	33.3
PO301	0	1	0	0	0	0	0	0	0	1	0	0.0
PO307	10	4	7	3	0	0	0	0	0	24	3	12.5
HI18	1	3	1	0	0	0	0	1	0	6	1	16.7

TABLE 24: Continued

Chert Types by Tumulus

Site	Mo	Ojc	Mk	Ind.M	Ind.O	Mn	Og	Ex	Or	Total	Total non-local	% non-local
HI208	0	0	0	0	0	0	0	0	0	0	0	--
PO304	2	0	4	0	0	0	0	0	0	6	0	0.0
DA250	1	6	1	0	0	1	0	0	0	9	0	0.0
DA216	7	4	1	0	0	0	0	1*	0	12	0	0.0
DA237	3	3	3	2	1	0	0	0	0	12	3	25.0
DA219	1	0	1	0	0	0	0	0	0	2	0	0.0
DA221	6	0	1	1	0	0	0	1	0	9	2	22.2
SR138	6	14	22	2	1	2	0	0	0	47	3	6.4
HE150	1	1	5	0	0	0	0	0	0	7	0	0.0
HI135	6	16	4	1	0	1	0	1	0	29	2	6.9
PO305	0	0	1	0	0	0	0	0	0	1	0	0.0
PO165	1	0	0	0	0	0	0	0	0	1	0	0.0
Total	318	368	225	56	15	23	3	23	1	103	108	
% of total	30.8	35.7	21.8	5.4	1.5	2.2	0.3	2.2	0.1	100.0	10.5	

*limestone
Mo = Burlington
Ojc = Jefferson City
Mk = Chouteau
Ind.M = Indeterminant Mississippian
Ind.O = Indeterminant Ordovician
Mn = Warsaw
Og = Gasconade
Ex = Exotic
Or = Roubidoux

each tumulus (see Fig. 26). This analysis was confined to tumuli where chert availability data were known. Yate's correction for continuity (as discussed in Thomas 1976: 279) was applied in all cases, except BE6-2, due to the small numbers in the "expected" cells.

The results (Table 25) show that, at the $\geq .05$ level of probability, six tumuli had assemblages of chert types which departed from the expected (naturally occurring chert distributions). In these six tumuli, it appears that there was some form of chert selection; either procurement from outside the site locus, or favoritism for certain types within the area. Such selection does not seem to have been significant at the other eleven sites.

Such conclusions are only tentative and incomplete. Ray's chert collections cannot be directly applied to the tumuli with a high degree of reliability. They represent the area closest to each tumulus for which intensive chert data are available, not the area immediately around each tumulus. The distance between the tumuli and the collection areas is given in Table 25, and range from 0.6 to 9.6 miles. Secondly, even if those data were available, it would not be expected that tools deposited in a tumulus were made there; rather, they were probably transported from a habitation site.

The comparisons with Ray's data are incomplete for two reasons. First, no chert availability data are available from outside the Truman Reservoir area. Thus, what seem to be significant differences in Table 24 are probably not. For instance, the high proportion of Jefferson City chert in the Truman and Pomme de Terre tumuli seems to be replaced by Chouteau in the Stockton tumuli. A map of the bedrock geology (Anderson 1979) of the region, shows more Mississippian cherts outcropping in the Stockton area, thereby explaining the archeological occurrence of Chouteau cherts. Only a detailed catchment analysis will verify whether or not cherts there were being selected in proportion to their natural abundance.

The second shortcoming in using Ray's collections for the sole comparison is that selection of chert for mortuary use may vary widely from selection for other purposes. More scarce or highly prized chert types may occur more frequently in a burial context, where increased energy expenditure is used to confer status. Future comparisons between mortuary and habitation site chert types will be a profitable test of this proposition.

A second goal of the chert type analysis was to determine the extent, if any, of interaction between southwest Missouri populations and others outside the region. All the

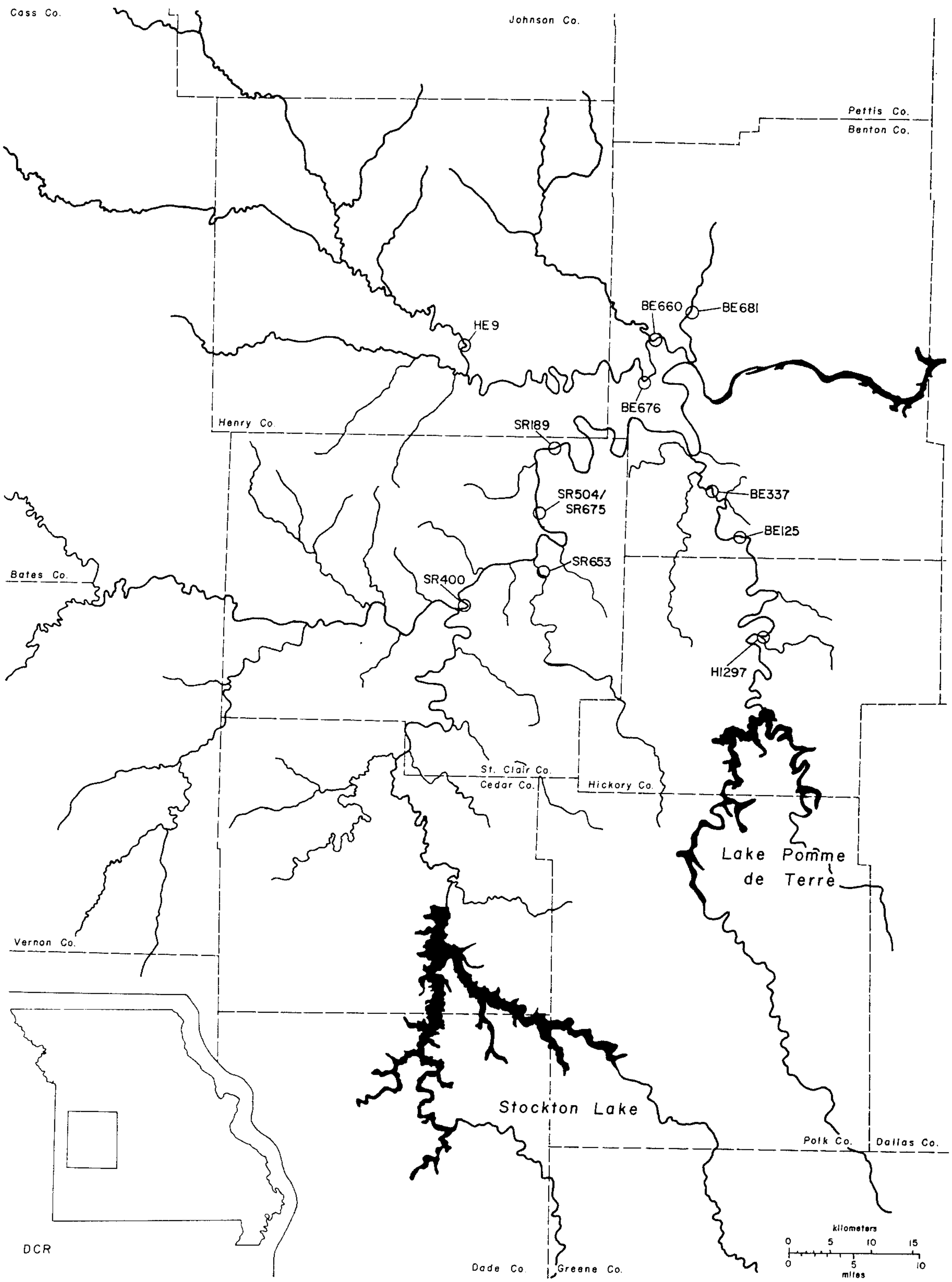


Figure 26. Location of chert collection areas.

TABLE 25

Chi-Squares: Tumulus Chert Utilization X Chert Availability

Tumulus	Distance from Collection area	Collection area		Burlington	Jefferson City	Chouteau	Other	Sample size	Chi-square	df	Probability
BE117	1.0	BE660	Obs Exp	3 1.4	7 11.2	4 1.4	-- --	14	5.23	2	.10 >p>.05
BE118	1.1	BE676	Obs Exp	3 1.5	3 7.5	4 1.0	-- --	10	9.12	2	.025 >p> .01*
SR141	2.3	SR653	Obs Exp	4 3.15	3 1.54	0 2.31	-- --	7	2.06	2	.50 >p> .25
SR111	2.1	SR653	Obs Exp	3 2.7	3 1.32	0 1.98	-- --	6	2.17	2	.50 >p >.25
BE3	0.6	BE337	Obs Exp	12 5.95	17 26.25	6 2.8	-- --	35	10.70	2	.01 >p >.005*
BE135	0.8	BE337	Obs Exp	3 1.36	3 6	2 0.64	--	8	3.16	2	.25 >p >.10
BE128	0.6	BE337	Obs Exp	4 2.55	8 11.25	3 1.2	-- --	15	2.43	2	.50 >p >.25
BE6-1	0.7	BE337	Obs Exp	10 6.97	24 30.75	7 3.28	-- --	41	5.35	2	.10 >p >.05
BE6-2	0.7	BE337	Obs Exp	81 36.55	106 161.25	28 17.2	-- --	251	79.97	2	p< .001*
BE6-3	0.7	BE337	Obs Exp	31 15.64	45 69	16 7.36	-- --	92	31.17	2	p< .001*
BE6-4	0.7	BE337	Obs Exp	0 0.68	3 3	1 0.32	-- --	4	0.23	2	.90 >p> .75
SR138	6.4 6.8	SR400/ SR653	Obs Exp	6 20.68	14 9.46	22 13.64	2 0.22	44	23.51	3	p <.001*
BE136	1.8 2.9	BE337/ BE125	Obs Exp	2 0.81	3 4.65	1 0.54	-- --	6	.91	2	.75 >p> .50
HI30c	6.6	HI297	Obs Exp	4 0.46	3 6.3	0 0.21	0 0.04	7	1.49	3	.75 >p >.50
HI149	5.7	HI297	Obs Exp	2 0.39	4 5.4	0 0.18	0 0.03	6	3.51	3	.50 >p >.25
HI18	8.3	HI297	Obs Exp	1 0.33	3 4.5	1 0.15	0 0.03	5	1.16	3	.90 >p >.75
HI135	9.6	HI297	Obs Exp	6 1.69	16 23.4	4 0.78	0 0.01	26	20.12	3	p< .001*

* indicates those chi-squares where H_o is rejected, when H_o = chert is utilized in direct proportion to its availability

raw material identified in Tables 23 and 24 as Roubidoux, Gasconade, Warsaw, Indeterminate Mississippian, Indeterminate Ordovician, and exotic were obtained outside of the Truman Reservoir area proper. The Roubidoux and Gasconade cherts may have come from as close as twenty miles to the east of the Truman Reservoir, but are not found nearer than that to any of the tumuli. Warsaw chert occurs to the south of Truman Reservoir and may occur locally near the Stockton tumuli, but is exotic to all other tumuli in the sample. The other three classes of chert were not represented in any of the type collection samples and are thus grouped into a "non-local" class. Discounting the Warsaw in the southern tumuli, some of which may have been locally available, 108 specimens, or 10.5% of the tools were made of non-indigenous chert. Of the forty-four tumuli which had identified chert, thirty contained chert obtained from outside the area.

APPENDIX D

BOTANICAL REMAINS FROM BURIAL MOUNDS IN SOUTHWESTERN MISSOURI

Frances B. King

Charcoal

Identifiable charcoal occurred in nine of the twenty-one sites (Table 26) and represented five types of wood. The most common charcoal taxa was oak (*Quercus* spp.), but there was also ash (*Fraxinus* spp.), sycamore (*Platanus occidentalis*), elm or hackberry (*Ulmus* or *Celtis*), and red cedar (*Juniperus virginiana*). All are common in the Ozarks, although red cedar was much less abundant prior to settlement than it is today (Howell and Kucera 1956). Red cedar was an important plant to Indians throughout the Midwest, with considerable religious and medicinal significance (Douglas 1976, La Fleshe 1928, Gilmore 1919).

Nuts and Seeds

The remains of acorns, hickory nuts (*Carya* spp.), hazelnuts (*Corylus americana*), and walnuts (*Juglans nigra*) occur in one or more of the burial mounds, sometimes in considerable quantity. The acorn remains are comprised entirely of carbonized nutmeats and must have been shelled prior to carbonization. The hickory nuts, walnuts, and hazelnuts are all represented by shells or fragments of nut shells and may have been either placed in the mounds whole or as discarded fragments.

Several mounds contain the remains of either known or potential cultigens. These include maize (*Zea mays*), squash (*Cucurbita pepo*), marshelder (*Iva annua*), lambsquarter (*Chenopodium* sp.), and sunflower (*Helianthus annuus*).

The most common seeds in the mounds are maize, which occurs in eleven mounds. The maize from some of the sites (PO300, PO307, and DA225) has previously been examined by Cutler and Blake (1973). Early maize in the Midwest was generally 12 to 14-rowed and appears to have derived from the Southwest. After A.D. 1000-1200, maize was primarily 8-rowed with strong row pairing, and the kernels were usually somewhat crescent-shaped and generally wider than long (Cutler and Blake 1973, Yarnell 1964). The maize from the burial mounds is described in Table 27, with row numbers determined as shown by Cutler and Blake (1973). The majority of the

Table 26. Botanical remains from southwestern Missouri Mounds.

Mound	Maize (Apprx. no. kernels) *Zea mays*	Sunflower *Helianthus annuus*	Squash *Cucurbita pepo*	Marshelder *Iva annua*	Chenopod *Chenopodium* cf. *buschianum*	Hackberry *Celtis* sp.	Mulberry *Morus rubra*	Dogwood *Cornus florida*	Acorns (cotyledons) *Quercus* sp.	Hickory nuts *Carya* sp.	Walnuts *Juglans nigra*	Hazelnuts *Corylus americana*	Charcoal
Be118													oak
Be135										4.9g			
Be136													oak
Be6													elm/hackberry
He147													sycamore
Po300	6000												
Po306	3												
Po307	6500									2,3g		0.1g	ash, cornstalk
Ce152	11	2c	7c	3c				1c		1.2g			
Ce150	26									..1g		.9g	
Ce123									1c				
Ce154										.1g			
Ce148	165		1c					2c		4.8g			
Ce104													oak
Da225	1000								3c	..1g		237nuts (127g)	
Da250													oak
Da246	60								2c		.1g		
Da219	4.					1u			16c		.1g		oak
Da222	120								15c				oak, ash, ceda·
Da226					cache								

ETHNOBOTANICAL REMAINS: SUMMARY

QUATERNARY STUDIES CENTER
ILLINOIS STATE MUSEUM

SITE ____________________

C=CARBONIZED U=UNCARBONIZED F=FRESH EMBRYO (CONTAMINATION)

PROVENIENCE		maize	sunflower	squash	marshelder	chenopod	hackberry	mulberry	dogwood	acorns	hickory nuts	walnuts	hazelnuts	charcoal			sucker scale
23Bc118														oak			
23Be135-20											4,9g						
23Be136-35														oak			
23Be6-112														elm/hackberry,			
113														elm/hackberry			
23He147														sycamore			
23Po300-57		140,5g															
30		77,5g															
61		280g															
20		133,5g															
8		1															
28		320g															
11		2															
23Po306-49		2															
44		1															
23Po307-12		403,5									1,5g		.1g	ash			
23		340,4g									.8g			cornstalk			

ETHNOBOTANICAL REMAINS: SUMMARY

QUATERNARY STUDIES CENTER
ILLINOIS STATE MUSEUM

SITE______________________

C=CARBONIZED U=UNCARBONIZED F=FRESH EMBRYO (CONTAMINATION)

PROVENIENCE		maize	sunflower	squash	marshelder	chenopod	hackberry	mulberry	dogwood	acorns	hickory nuts	walnuts	hazelnuts	charcoal			sucker scale
23Da225-42		62															
72		10															
10		5															
25		1								2c							
39										1c	1frag		120g				
77											1frag		9.5g				
22									1c		1frag		108g				
68		172g															
23Da250-41														bark			
32														bark			
42														oak			
23Da246-30		9								2							
44		51						1c				1frag	2whole 3frag				
23DA219-44							1						.1g	oak			1
7		3															
48														bark			
19		1								16							
23Da222-72		11.5g															
18										15							
23Da216 Cairn														oak,	ash	red	cedar
23Da226-49		27 (+cob frag)															
27						cache											

ETHNOBOTANICAL REMAINS: SUMMARY

QUATERNARY STUDIES CENTER
ILLINOIS STATE MUSEUM

SITE____________________

C=CARBONIZED U=UNCARBONIZED F=FRESH EMBRYO (CONTAMINATION)

PROVENIENCE		maize	sunflower	squash	marshelder	chenopod	hackberry	mulberry	dogwood	acorns	hickory nuts	walnuts	hazelnuts	charcoal			sucker scale
23Ce150-25		26 (cob frag)									.1g		.1g				
23Ce152-23											.5g						
12											.6g						
13		1															
18		9	1c	2c	1c			1	1								
16				5c	2c												
62											.1g						
25		1											.8g				
23Ce123-93G										1c							
23Ce154-15											.1g						
50											.1g						
23Ce148-85		16		1c					2c		4.8g						
84		17.1g															
23Ce104														oak			

TABLE 27

Corn from Southwest Missouri Tumuli

Mound	Age*	Description
PO300	Mississippian	8, 10, 12 rowed (Cutler and Blake 1973)
PO307	Mississippian	8, 10, 12 rowed (Cutler and Blake 1973)
DA225	Mississippian	10-12 rowed not crescent, 8-rowed crescent (Cutler and Blake 1973)
PO306	Woodland+	8 rowed not crescent (1 grain)
DA246	Woodland	8-10 rowed crescent
DA219	Woodland+	8 rowed crescent shaped (2 grains)
DA222	Woodland	8, 10, 12 rowed, mostly crescent shaped
DA226	Woodland+	8, 10, 12 rowed, some crescent shaped
CE150	Woodland+	8-10 rowed, crescent shaped
CE152	Woodland+	8-10 rowed
CE148	Woodland	8, 10, 12 rowed crescent, 8 rowed not crescent, all kernels small

*These temporal determinations were made early in the analysis of the archeological assemblages and those with a + probably date to the later Mississippian period.

Woodland sites appear to have predominantly kernels from 8-rowed cobs and are frequently crescent-shaped.

The marshelder achenes from sample CE150 measure 5.3x3.5 mm, 6.2x4.5 mm, and 5.8x3.5 mm in length and width respectively, falling within the size range of suspected cultivated marshelder (Yarnell 1972). The sunflower achenes measure 6.4x3.1 and approximately 7.4x4.2 mm, also falling within range of cultivated sunflower (Heiser 1954). All of the marshelder and sunflower seeds are carbonized.

The squash seeds are also carbonized and measure 8.2x 6.6 mm, 9.6x5.6 mm, 9.8x5.9 mm, 10.0x5.7, 10.8x8.0, 10.6x6.0, and 10.9x5.8 mm from CE150 and 9.5x5.3 mm from CE148. Although small, they have a relatively high length/width ratio and probably represent a small pumpkin or summer squash rather than the relatively flat and broad-seeded variety from Phillips Spring (23HI216) or Boney Spring (23BE146).

Mound DA226 contained a large concentration of charred chenopod seeds. The seeds massed together in clumps, suggesting they were relatively fresh when carbonized so that the internal contents expanded and boiled out. Several clumps have small pieces of an apparent bag still attached to the bottom. The bag is made of a grass woven together with spaced twining such as is shown by Gilmore (1930) as having come from Ozark bluff shelters. One fragment has a section of what appears to be carbonized hide from some relatively short-haired animal underlying the grass bag and chenopod seeds.

The chenopod seeds are charred to varying degrees. Those that are best preserved have a reddish, slightly reticulate pericarp and a sharp beak and are similar to the description of *Chenopodium buschianum* given by Asch and Asch (1977). They average 1.6 mm in diameter (range 1.2-1.8 mm for 30 seeds) and although carbonized (and thus probably smaller than uncarbonized seeds would be) also fall within the size range for *C. buschianum*. Asch and Asch (1977) feel that this is the species found in Ozark bluff shelters.

In addition, there are seeds of dogwood (*Cornus* cf. *florida*), a fragment of what appears to be carbonized mulberry fruit with seeds (*Morus rubra*), and a hackberry seed (*Celtis* sp.). All might easily be accidental inclusions in the sites, since they are common in Ozark forests.

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APPENDIX E

PRELIMINARY THERMOLUMINESCENCE DATES FROM BURIAL TUMULI IN SOUTHWEST MISSOURI

M. Mandeville

THE PROBLEM

The problem in the present study was to determine the dates of a number of tumulus sites in the Truman Reservoir in southwest Missouri using thermoluminescence (TL) measurement. Samples consisting of chert and human teeth from ten tumuli were run. The following is a report of the methods employed and the results of the analysis.

The technique of dating by TL depends upon the fact that nuclear radiation causes ionization of matter through which it passes, i.e., electrons are dislodged from their atomic orbits. Some of these electrons become trapped in a high energy state at defects in the crystal lattice. The process is cumulative until the sample is saturated (all defects are filled) or until it is drained – at which point it begins all over again.

THE SAMPLE

Thirty-eight items from 10 sites were presented for dating in this study: 30 chipped stone artifacts and eight human teeth.

Chert:

Of the 30 chipped stone artifacts, 13 (representing 7 sites) were selected as showing evidence of having been heat treated or burned. Since this material is almost pure SiO_2 (97-99% - Frondel 1962: 221), essentially all TL may be attributed to environmental rather than to internal irradiation; radon escape is thus of no consequence.

A shortcoming of this technique is that it can date material only if it has been heated to at least 400°C. Since a temperature of slightly over 300° has been found to be adequate for the pretreatment of some varieties of chert (Mandeville and Flenniken 1974), not all heat treated chert artifacts will be amenable to dating. A date of cultural significance can, of course, be derived only if the material has been heated – intentionally or unintentionally – in a

cultural context. In spite of these and other complicating factors, a good sample can be expected to yield a date accurate to within 5% to 10% of the actual date (Aitken 1974: 110).

Biological Materials

The measurement of TL in bones and teeth has been less thoroughly investigated than that in ceramics and lithics. The comparative homogeneity of these materials and a typically low level of internal radioactivity (Christodoulides and Fremlin 1971) indicate advantages in sample preparation and interpretation similar to those of chert. The principal problems appear to be the creation of TTL in the preparation of powder samples and chemiluminescence (CL) which results from the heating of organic material and tends to mask the TL (Christodoulides and Fremlin 1971). The first of these problems can be alleviated through the use of solid samples; the second, i.e., CL, persists. A completely satisfactory method of deorganicizing bone samples has not yet been developed (Aitken 1974: 127). Variable success has been reported in the suppression of CL through use of an oxygen-free nitrogen atmosphere in the chamber of the heater (Rowlett et. al. 1976; Christodoulides and Fremlin 1971). In the case of teeth, however, the problem of CL can be avoided by preparing samples from the external enamel layer which is largely inorganic* (Clement 1963; Gray 1977).

SAMPLE PREPARATION

Chert

In sample preparation, as with pottery, the outside "skin" of the artifact is removed and discarded thus avoiding the problem of α and β attenuation and of bleaching. The comparative homogeneity of chert obviates the necessity of fractioning the sample which is taken from the interior of the artifact and may either be crushed to a powder or used in a solid state. The latter technique reduces the danger of creating tribothermoluminescence (TTL) in the process of sample preparation (Gosku, Fremlin, et al. 1974) and, since surface area for a given weight is less with a solid sample, spurious TL is minimized (Aitken 1974: 97; Christodoulides and Fremlin 1971: 257: Burleigh and Seeley 1975).

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*Melcher and Zimmerman (1977) found the uranium content of a variety of cherts varied from 0.3 to 10 ppm; Rowlett (MS) found that ca. 1/2 of cherts investigated had no measurable internal radioactive impurities and in the remaining 1/2 the amounts were mostly insignificant. As a practical matter, in this study, internal radiation has been assumed to be non-existent.

Samples were removed from the chipped stone artifacts by pressure flaking with the threaded end of a 10-40 bolt. The first flake (exterior surface of the artifact) which contains α and β radiation damage, was discarded. Several flakes were then removed from the interior of the artifact. Each flake, in turn, was glued to the head of a 16 penny nail with Superglue (Krazy Glue - containing cyanoacrylate) and smoothed by rubbing on a piece of 320 grit sandpaper. The sandpaper was kept lubricated with water during this process to minimize the production of tribo TL. When one side of a sample was smooth, the glue was dissolved by soaking in acetone, the sample was reversed on the nail, and the other side was similarly smoothed. Each sample was then rinsed in Ethanol alcohol and placed in a sterile plastic vial.

Teeth

Samples from the teeth were roughly shaped with a knife blade. They were then smoothed by the same procedure used for the chipped stone. Only the white enamel exterior was used since this has the lowest organic content.

According to Gray (1977: 877-878), the organic component of bone is ca. 33%, that of dentine 28%, but in the case of enamel it is only 3.5%. Clement (1963: 263-264) cites two studies by J. Staz wherein enamel was found to contain 4.19% and 1.46% organic material contrasted with over 38% in dentine.

READING THE SAMPLES

After taking a series of background readings for error calculation, each sample in turn was placed on the planchet in the sample drawer of the heater and heated to 370° or 390°C (ideally 400°). The amount of TL, indicated by the digital display on the photomultiplier, was recorded and a glow curve was obtained through the use of an attached recording device (plotter).

Each sample was then drained at 400°C (this temperature was maintained for 2 hours) in a small kiln and was then reirradiated with a dose approximately equal to the annual dose (dosimetrically determined) multiplied by the estimated date (BP) of the site. Approximate duplication of the natural TL of the sample is necessary because the rate of accumulation of TL is not linear. If observed (i.e., natural) TL and induced TL readings differ by more than 5% recalculation of the age of the site and draining and reirradiation of the sample at the recalculated level are called for.

difference was small (less than .1 nc) an average of the two readings was used for computing the annual dose rate.

RESULTS

Teeth

Twenty samples were prepared from the 8 teeth and natural TL was measured (Table 28). The samples were then placed in the kiln for draining. The temperature was brought up to 400°C and the controls were set to maintain this temperature. Three hours later the temperature had risen to 600°C; all samples were calcined and had to be discarded.

Twelve new samples were prepared (2 from each of the 6 remaining teeth – two teeth had been completely destroyed in the process of preparing the first samples) and the natural TL was measured (Table 28). The No. 1 member of each pair of samples was placed in the kiln for draining and controls were set at what was believed to be an appropriate level (recalculated). Two hours later the kilm temperature had reached 500°C; all samples were again calcined and had to be discarded. During all succeeding attempts at draining, the kiln temperature was continually monitored.

The remaining six samples were then placed in the kiln; temperature was raised to 400°C and maintained for one-half hour. Two samples were then placed in the TL reader to ascertain whether draining had been adequate. Partial draining appeared to have been achieved with one of these samples, BE6 M2 D(2); the other, CE104 41 (2), showed a slight increase in TL over the original reading (Table 29).

The same two samples were returned to the kiln; temperature was raised to 400°C and maintained for 1 hour. This decreased, but did not eliminate, the TL from CE104 41 (2); BE6 M2 D (2) registered an increase in TL over the previous reading (Table 29).

These two samples were returned to the kiln again and heated at 400°C for two hours. TL decreased in both samples though BE6 M2 D (2) still read higher than after the one-half hour draining attempt (Table 29).

All six samples were then placed in the kiln and heated for five hours at 400°C, and another set of TL measurements was made. These indicate that drainage has not been achieved with any of the samples. BE6 M1 55 (2) shows an increase in TL over the original reading; PO307 116 (2) shows only a slight decrease (Table 29). A shortage of time precludes further attempts at draining these samples. Therefore, no dates can be calculated at this time.

DOSIMETERS

Type: Ca-Fl

Transportation

Dosimeters (drained) were carried to the field in lead containers.

Placement

Two dosimeters were wrapped in Saran wrap and placed, as nearly as possible, in the location from which the material to be dated had been removed. (The Saran wrap serves a dual purpose: it protects the dosimeters against loss in the soil and shields them from bombardment by α particles (Aitken 1974: 105). In the case of the mounds, which had been excavated some years previously, such exact placement was not possible. The dosimeters were left implanted in the sites for about 6 weeks (in two cases - BE135 and BE136 - for one year). They were then removed and, still in Saran wrap, sealed in plastic bags with a small quantity (Ca. 8 oz.) of the surrounding soil and returned to the laboratory.

Reading

The dosimeters were removed from the Saran wrap with teflon coated tweezers and were either air dried or blotted dry with toilet tissue. They were then placed in the chamber of the heater and heated to 400°C; the amount of TL, as indicated by the digital display of the photomultiplier was recorded on the appropriate form.

Before each reading session a minimum of 3 background readings was recorded. The standard deviation of these readings (as a percent of the dosimeter TL reading) is one of the known error factors of this dating technique.

Calculations

The figure derived from this procedure is the amount of TL (measured in nana-Coulombs) accumulated by the dosimeter while it was in the soil. The source of this TL is radioactive elements within the soil. With a knowledge of the number of days the dosimeters were exposed to this radiation, the expected annual dose rate can be calculated. This is then converted from nc to Rads (1 rad - 2.95 nc).

In no case did both members of a pair of dosimeters yield exactly the same reading. In cases where the difference was great (.1 - .6 nc) one member of the pair was wet, dirty or both, and this reading was discarded. In cases where the

TABLE 28

Thermoluminescence Results — Teeth

Dosimeter No.	Site	Sample No.	Estimated Date	Annual Dose	Sample TL	Sample Minus Background
T-4	PO306	64	1000 B.P.	.3093220		
		1X			3.551	2.65625
		2X			3.549	2.67725
		3X			2.073	1.2205
T-7	CE104	41	.3510232			
		1X			1.602	.80375
		2X			1.564	.7565
		1			4.132	2.90275
		2			3.052	2.1335
T-10	PO307	B2	1000 B.P.	.2145226		
		1X			4.176	3.25175
		2X			3.766	2.8635
		3X			3.083	2.17475
T-10	PO307	116	1000 B.P.	.2145226		
		1X			1.570	.8315
		2X			2.267	1.56375
		1			2.415	1.8125
		2			3.591	2.9515
T-11	BE6 M2	D	1500 B.P.	.2671231		
		1X			4.880	4.206
		2X			4.971	4.3045
		1			4.971	4.01775
		2			12.600	11.7445

TABLE 28: Continued

Thermoluminescence Results — Teeth

Dosimeter No.	Site	Sample No.	Estimated Date	Annual Dose	Sample TL	Sample Minus Background
T-13, 14	BE6 M1	55	1500 B.P.	.231889		
		1X			4.229	3.55625
		2X			4.037	3.33925
		1			9.301	8.5725
		2			7.873	7.03625
T-19, 20	BE128	19	1500 B.P.	.1782186		
		1X			1.943	1.101
		2X			1.372	.536
		3X			1.635	.8115
		1			9.727	8.51875
		2			15.0	14.172
T-21	BE3	81	1500 B.P.	.2277921		
		1X			1.740	.902
		2X			1.316	.46575
		3X			2.133	1.23175
		1			13.1	12.04875
		2			21.5	20.60825

TABLE 29

Teeth - Draining Trials

Dosimeter	Site/ Sample	Sample TL	-Background	400^{o} ½ hr.	-Background	400^{o} 1 hr.	-Background	400^{o} 2 hr.	-Background	400^{o} 5 hr.	-Background
T-7	CE104/ 41 (2)	3.052	2.1335	2.889	2.15375	2.373	1.781	1.703	.896	2.194	1.252
T-10	PO307/ 116 (2)	3.591	2.9515							3.810	2.868
T-11	BE6 M2 D (2)	12.6	11.7445	4.833	4.10466	9.500	8.908	6.219	5.412	4.321	3.379
T-13,14	BE6 M1 55(2)	7.873	7.03625							9.801	8.859
T-19,20	BE128 19 (2)	15.0	14.176							5.668	4.726
T-21	BE3 81 (2)	21.5	20.60825							6.504	5.562

In view of the difficulty encountered with draining the dental samples, it seems that use of the additive technique may be indicated. This, however, demands two identical sized samples which can only be achieved through powdering — with the attendant problem of TTL.

Lithics

TL measurements were made of 31 samples taken from 10 artifacts representing 6 sites. The results are presented below in tabular form (Table 30). Three of the artifacts (9 samples, 2 sites) appear to have been heated but not to the critical point of 400°C. From the remaining 22 samples (6 artifacts) dates were calculated for 4 sites.

The dates calculated for DA225 and HI135 could hardly have been closer to the estimates (Table 31). The C-14 dates for HI135 are considered by Wood (1976: 311-312) to be much too late in view of the presence of an Afton point, a Late Archaic form dating from 3000 BC - 1000 BC (Chapman 1975: 186). The TL dates support Wood's judgment.

Dates for the other 3 sites are, for the most part, within an acceptable range of the estimates. Artifact #41 (PO306) is a small "bird point." Its late TL date (370 BP) may indicate that it is an intrusive artifact. Artifact #111 (PO307) dates much earlier than expected. The artifact is a small nondiagnostic tool fragment lacking temporal indicators. It is possible that this piece was not heated to 400°C prehistorically. If such was the case, what is being measured here is, in part, geological rather than cultural time.

CALCULATIONS

To Calculate Annual Dose:

$$\frac{\text{Dosimeter TL (-Background)}}{\text{Days in ground}} \times 365 = \text{nanocoulombs/year.}$$

1 rad = 2.95 nc.

$$\frac{\text{nc/yr}}{2.95} = \text{annual dose (rads/yr)}$$

Error: SD of background/dosimeter TL = $\%\pm$

To Calculate Dates:

$$\frac{\text{Natural TL (- av. background)}}{\text{Induced TL (- av. background}} = \frac{\text{X (calculated date)}}{\text{years represented by irradiated dose (irradiated dose/av. annual dose)}}$$

TABLE 30

Results of Thermoluminescence - Lithics

Dosimeter/ Site	Artifact #	Sample #	Natural TL	Dose	Induced TL	Date BP	Dose	Induced TL	Date BP	Dose	Induced TL	Date BP	Dose	Induced TL	Date BP	Dose	Induced TL	Date BP
T-15,16	18	1	2.8373	802.0	.3807	22,599	5000	4.9487	10,839	2599.4	.98	2,845	3522	3.645	10,365			
		2	1.5563	802.0	.2547	18,529	5000	3.5537	8,279	2599.4	.989	19,386	3522	1.206	17,178			
HI135		3A	.157										3552	.263	9,939			
		4A	.118										3552	.242	6,483			
		5	.156													619	.1283	2,884
		3	1.9293	802	.1187													
		4		802	-.0683													
	55	1	.3251	201.8	.387	791												
T-10		2	.2501	201.8	.296	795												
PO 307	111	1	5.0652	201.8	.783	6,087	9998.24	55.885	4,224	4009.1	16.216	5,837	1031	4.079	5,968			
		2	.2512	201.8	.069	3,425	9998.24	12.985	902	4009.1	3.968	1,183	1031	1.207	1,000			
		3	.7212	201.8	.296	2,483	lost sample											
		4	1.4113										1031	.911	7,446			
		5	1.3423										1031	1.173	5,500			
		6	1.6583										1031	1.503	5,268			
		7	.8773	very small sample									1031	.453	9,520			
T-4	4	1	.5906	201.8	.613	628												
		2	.0672	201.8	.346	127	sample too close to surface of artifact											
PO 306	41	2	.1042	201.8	.182	373	99.99	.947	355	99.7	.163	206						
T-5,6	49	1	.3332	404.2	.332	983												
DA 225		2	.3032	404.2	.349	851												

TABLE 30: Continued

Results of Thermoluminescence - Lithics

Dosimeter/ Site	Artifact #	Sample #	Natural TL	Dose	Induced TL	Date BP	Dose	Induced TL	Date BP	Comments
T-13,14	108	1	5.0842	404.2	.3737	23,715	2996.96	.843	77,945	not heated to 400°
BE 6		2	2.7712	404.2	.4937	9,784	2996.96	1.3775	25,999	
MD. 1										
	110C	1	5.2783	404.2	2.8487	3,597	1199.84	2.308	13,178	not heated to 400°
		2	1.0223	404.2	.1947	9,153	1199.84	.323	16,376	
		3	.5673	404.2	.2277	4,343	1199.84	.313	16,899	
		4	1.5443	404.2	.3557	7,568	1199.84	.602	13,295	
T-11	123J	1	3.7962	404.2	.4677	12,281	2996.96	1.1425	37,277	not heated to 400°
BE 6		2	2.3322	404.2	.3227	10,935	2996.96	.564	46,391	
MD. 2		3	1.5612	404.2	.2547	9,275	2996.96	.483	36,262	

TABLE 31

Thermoluminescence Dates

Site	Artifact	No. of Samples	Estimated Date	Calculated Date
PO306	4	2	1000 B.P.	643 BP±30
	41	2		370 BP±30
DA225	49	2	1000 B.P.	*997 BP±49, 865 BP±43
PO307	55	2	1000 B.P.	807 BP±40, 811 BP±4
	111	7		5283 BP±263
HI135	18	7	3000 B.P.	2865 BP±256, *2864 BP±427
BE6 M2	123J	3	500 B.P.	Not heated to 400°C
BE6 M1	108	2	500 B.P.	Not heated to 400°C
	110C	4		Not heated to 400°C

*Indicates most reliable of a series of dates.
1. C-14 dates: 1430 BP±135; 1565 BP±105 (Wood 1976)
2. Estimated dates provided by Dr. Donna Roper are based on stylistic evidence from excavated materials, principally lithics.

Error Factors:

Known sources of error in dating which can be calculated are:

(1) Variations in the TL reading appratus — figured from background readings.

(2) Accuracy of exposure for induced TL.

DEFINITIONS (GLOSSARY)

Dosimeter: a highly sensitive artificial phospher — lithium flouride, calcium flouride, calcium sulphate — used to measure accumulated exposure to radiation (Aitken 1974: 90).

Rad: (Radiation Absorbed Dose) — a unit of measurement defined as the absorption of 100 ergs/gram (Aitken 1974: 86).

Natural TL (Original TL): the TL resulting from internal and/or environmental radiation.

Artificial TL (Induced TL): the TL resulting from exposure to a known dose of nuclear radiation from an artificial radioisotope source (in this study, Co-60).

LABORATORY APPARATUS

The laboratory apparatus used in this study consisted of:

(1) The heater - Harshaw Thermoluminescence Detector, Model 2000A

(2) The photomultiplier - Harshaw Automatic Integrating Picoammeter, Model 2000B

(3) The plotter - Esterline Angus, Model 575

(4) The kiln - Blue M Lab Heat Muffle Furnace, Model M 15A-1A.

Reirradiation was done with g rays from CO-60 by Vickie Spate at the Nuclear Reactor of the University of Missouri at Columbia.

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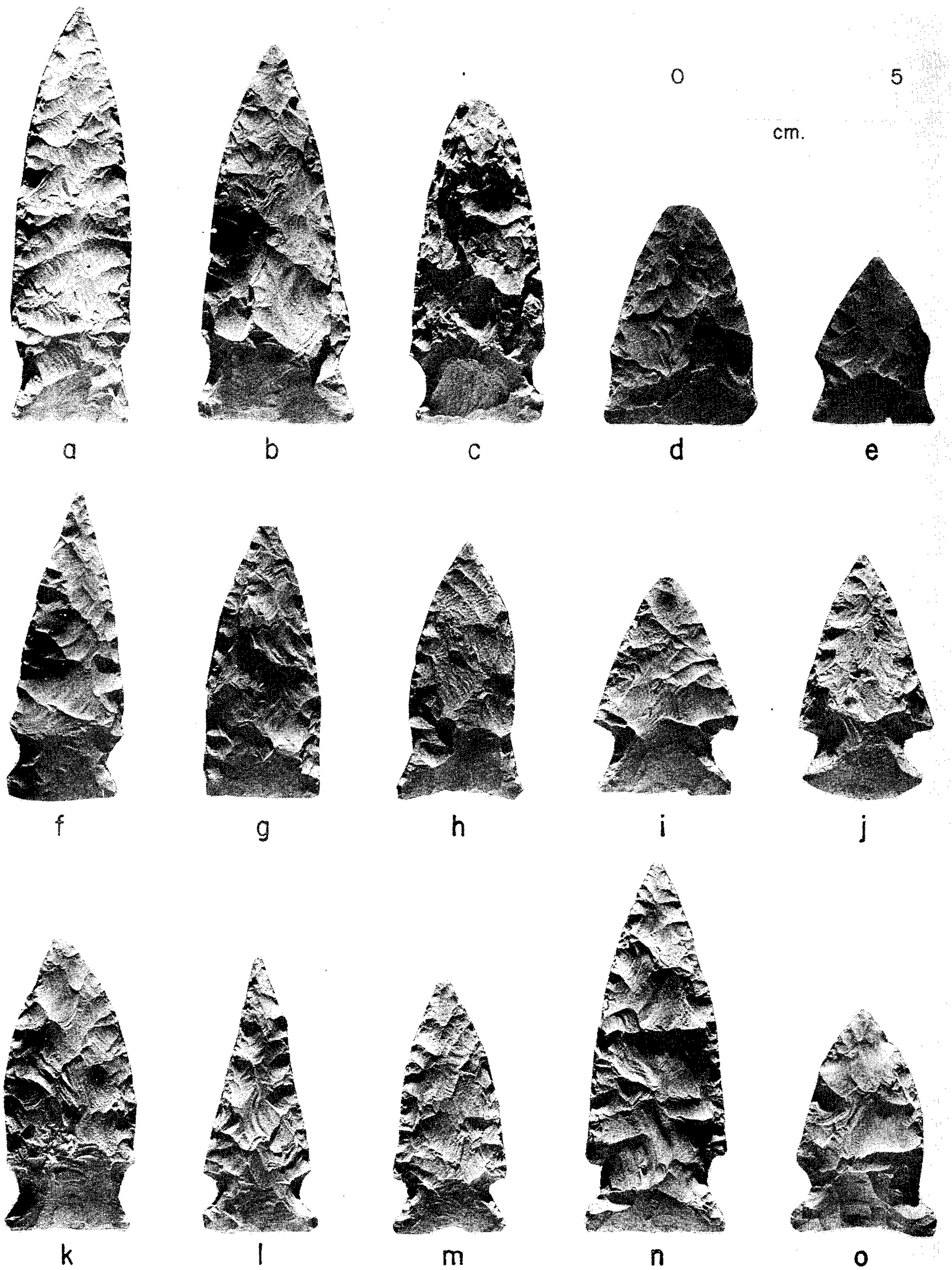

Plate 1. Rice Side-Notched a-h; Cooper-like Corner Notched i-o.

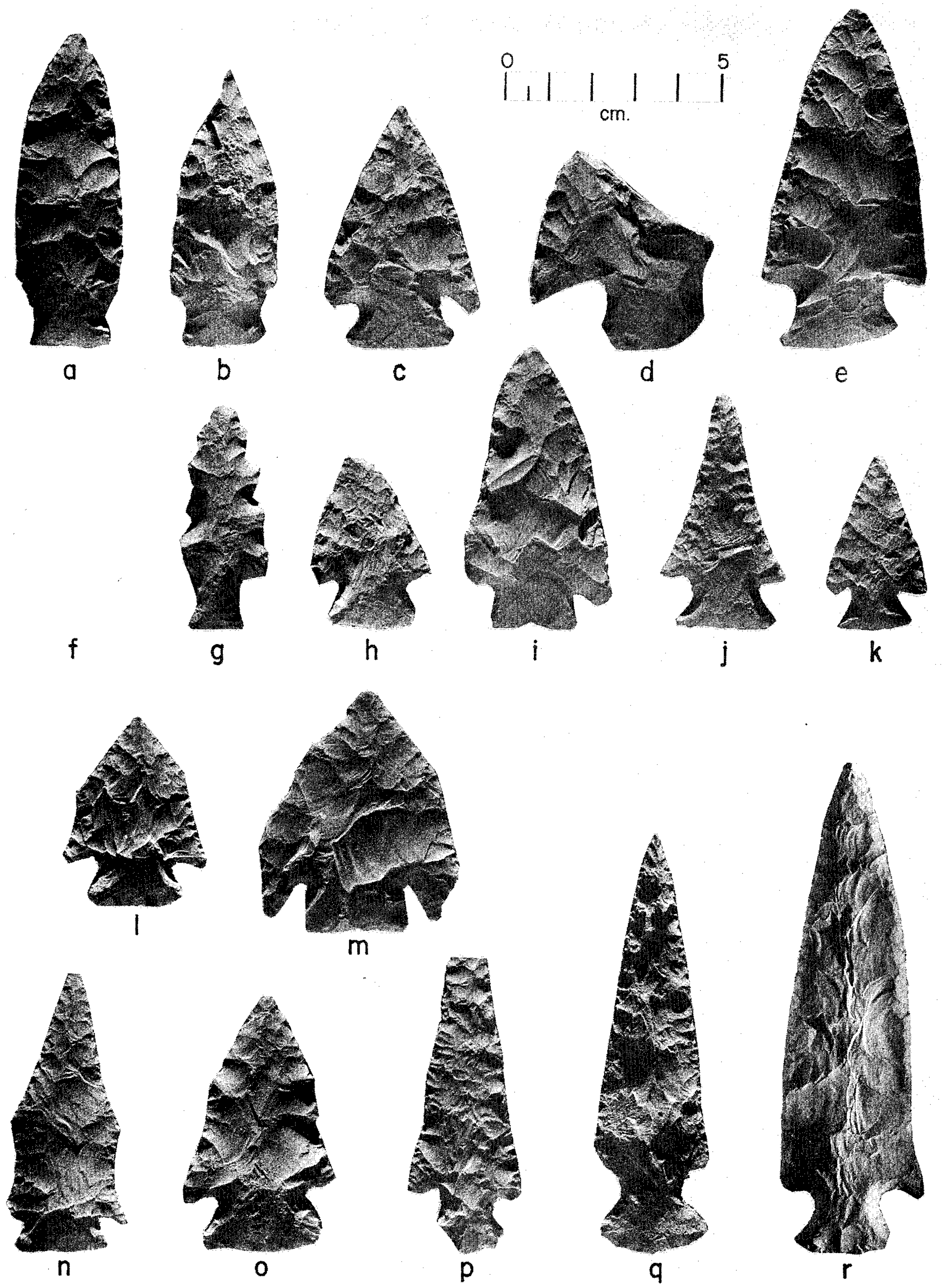

Plate 2. Rice Side-Notched Variant, a-b; Norton, c; Snyders, d; Weber, e; Delaware-like, f; Table Rock Stemmed, g; Guffy-like, h; Marshall, i; McConkey, j-k; Afton, l-o; Cupp, p-q; Etley-like, r.

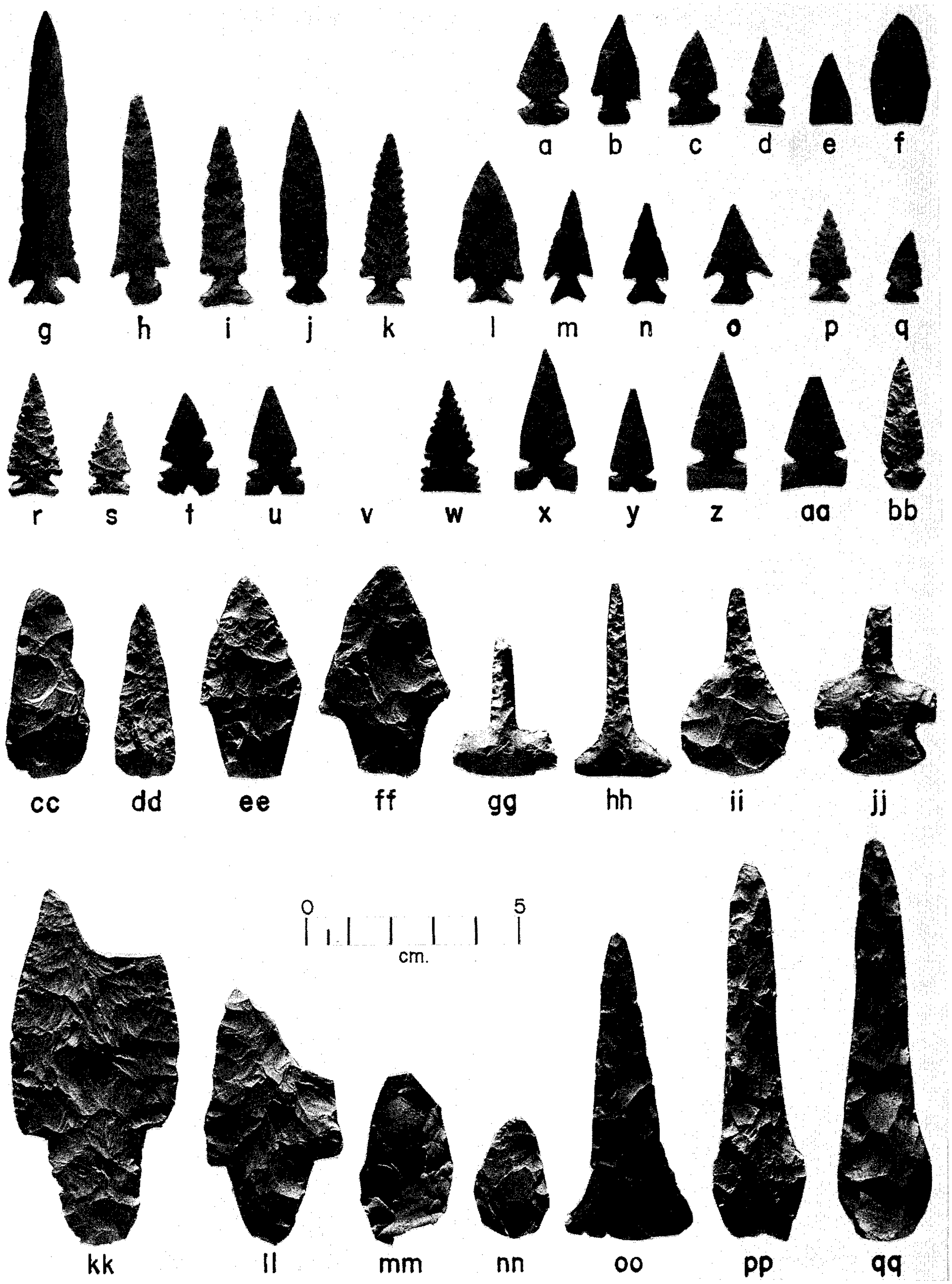

Plate 3. Late Woodland, a-b; Reed, c-d; Fresno, e-f; Scallorn, g-q; Haskell, r-s; Huffaker, t-w; Harrell, x-y; Washita, z-aa; Keota, bb; White River Elliptical, cc-dd; Standlee, ee-ff; F-Drills, gg-jj; Waubesa, kk; Gary, ll; Crisp Ovate, mm-nn; Other Drills, oo-qq.

PART I.

MORTUARY ANALYSES

NUMBER 2.

PREHISTORY OF SOUTHWESTERN MISSOURI: HUMAN SKELETAL AND MORTUARY DYNAMICS

by

Sharon L. Brock

ACKNOWLEDGMENTS

As with most major endeavors, this work represents the result of energies other than my own. I, of course, claim full responsibility for the contents, but several people were instrumental in its conception, perpetuation, and finalization. Foremost among these is Susan K. Goldberg without whose strength and support this research would not have begun. Susan shared and gave so much to me during our work together that to say it briefly: through her I began to "think like an anthropologist" and to have confidence in myself as a researcher. Most importantly, she has never failed as a friend even after three years of listening to my rantings, coping with my frustrations, and enduring my moods. Special thanks also extend to Donna Roper who, perceiving the value of a conjunctive approach to archeological research, gave me the opportunity to show my mettle and conduct the bioanthropological investigations.

The members of my M.A. committee merit individual recognition as each gave differently to this report. Dr. Samuel D. Stout initially vouched for my worth as a student and relentlessly demanded my best effort in equal return for his. He also provided prudent advice regarding my dealings with other faculty members and my career ambitions as a bioanthropologist. Dr. W. Raymond Wood unselfishly gave access to his data from the burial tumuli within the study area. Dr. B. Miles Gilbert tempered my enthusiasm with realism, and was a ready aid station when the pressures became too great. The energy and time Dr. Robert Benfer gave to me and to my work was phenomenal. His interest was genuine and his excitement contagious; I never left a conference with him satisfied, but rather exploding with an eagerness to discover how, why, and who-else.

Forming the parts into a whole and packaging a final product required much special assistance. Susan L. Brown and Andy Jacks drafted the figures, and I applaud their patience and skill. Jean Sparks typed the manuscript, including all the tables which was an awesome feat in and of itself. My gratitude and deep appreciation for their talents are extended to each one.

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ABSTRACT

The human skeletal and mortuary dynamics from prehistoric burial tumuli in southwest Missouri were investigated in an attempt to discover the nature of the development and adaptation of the aboriginal inhabitants of the area. Data were compiled from specific skeletal sources and from traits pertinent to the interment features of each tumulus. A total of 48 tumuli yielding 302 individuals comprised the sample. Analyses relevant to demography, social organization, nutrition and health were conducted in addition to the traditional osteological evaluations. Each separate analysis contributed toward the overall documentation and interpretation of human adaptation in the Central Osage River Basin Region of southwest Missouri.

The approach taken in the assessment of the skeletal biology was supplied by the data itself: corn was recovered from some but not all of the burial tumuli. A heavy reliance upon corn, a high carbohydrate, low-protein food, is known to create nutritional deficiencies which are often expressed skeletally. An evaluation of the significance of corn provided a productive means of ascertaining intertumuli variability and a ready form for cross-cultural comparisons.

Multivariate and bivariate procedures were employed in testing intertumulus variability. When possible, the results of the tests were contrasted with comparable data from neighboring Woodland and Mississippian populations in an effort to establish a biological relationship between the southwest Missourians and their neighbors.

Biological and cultural homogeneity and continuity were indicated in the burial program of prehistoric southwest Missouri. A basic cultural system, principally composed of traits typical of a generalized Woodland pattern, was suggested from the analyses of the mortuary data. Within this system there was some regional variation as would be expected in an area where the adaptation was primarily a hunting and collecting strategy practiced by small, mobile groups of people. The contribution of corn to the diet was minimal, being a supplemental rather than a staple food item.

CHAPTER I

INTRODUCTION

Problem Orientation

The purpose of this research may be generally stated as a question: What was the nature of the development and adaptation of the aboriginal population in the central Osage River Basin Region of southwest Missouri? Inherent in that query is the attempt to explain the culture-history of a once living people, the primary avenues of investigation being archeologically observable behaviors regarding death and the recoverable skeletonized remains of the dead. The endeavor to explain a specific set of human behaviors and interpret those behaviors within the realm of biology and culture set this research within an anthropological frame. Also, the particular approach taken is implied, and is made explicit in the following passage:

> "Humans survive not through cultural adaptation nor through biological adaptation, but through _bio-cultural_ adaptation. The most appropriate treatment of the study of humans is, therefore, a biocultural approach" (Blakely 1977: 1, emphasis mine).

The data gathering techniques used by the physical anthropologist adopting this approach are unchanged. Yet, the perspective applied to these data differ in that explanations contributing to reconstructing culture-historical processes are sought (see Blakely, ed. 1977). The present study, utilizing mortuary-site, bioarcheological data, is an attempt to further advance the knowledge of southwestern Missouri prehistory through contributions pertaining to demography, nutrition and health, and social organization.

The Region: Environment and Archeology

The study area and its relation to the major physiographic regions of southwest Missouri are shown in Figure 1. The physiography and environment of the area are only briefly treated here, and then exclusively in regard to the possibility of an impedence to population or settlement dispersion and to gene flow. The interested reader is referred to the readily available and highly recommended volume edited by W. R. Wood and R. B. McMillan (1976) which presents a diversity of topics pertinent to human-land relations in southwest Missouri. Also, the most recent, thorough, and in-depth compendia detailing the cultural resources of the central Osage River Basin are

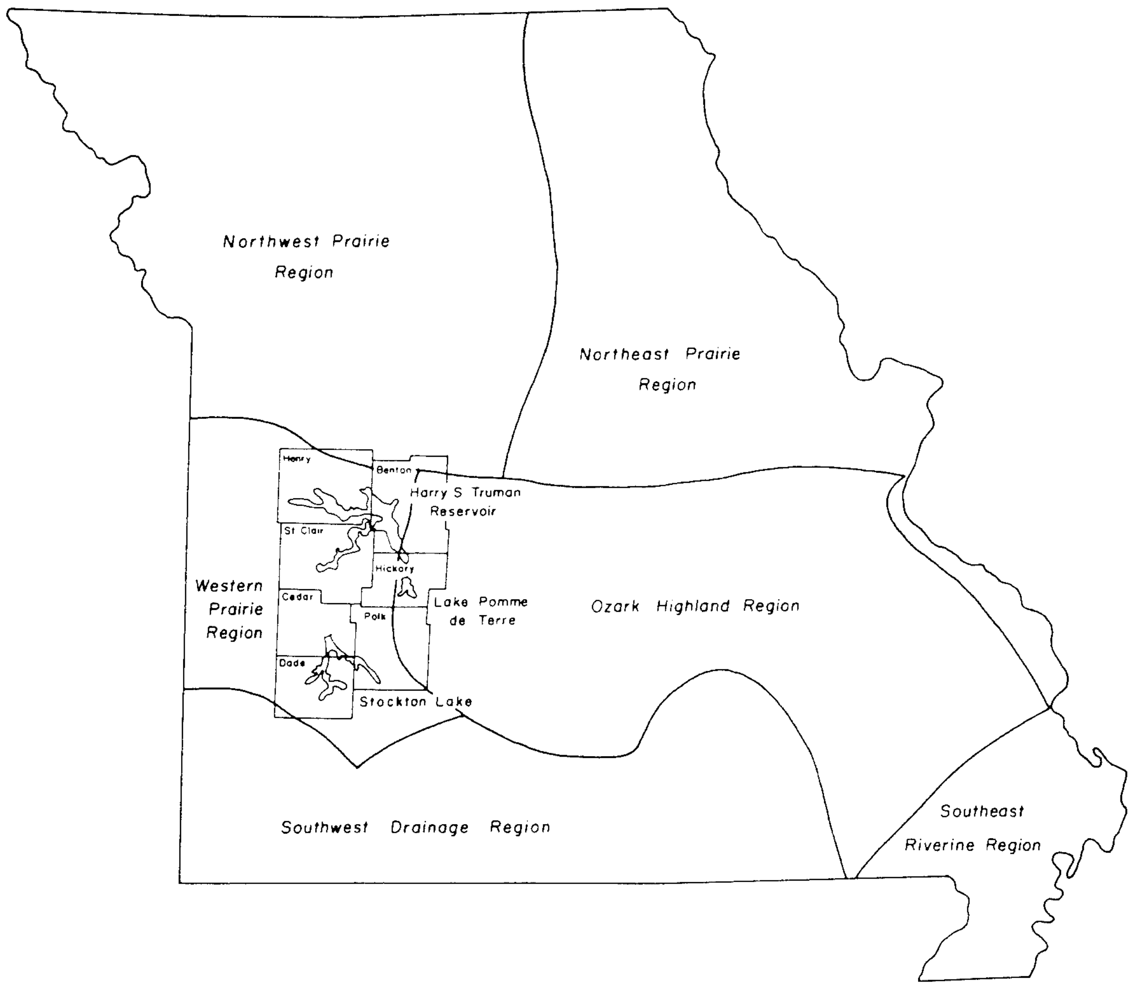

Figure 1. Relation of the study area to physiographic regions of Missouri (Chapman 1975: 3).

the numerous reports of the Harry S. Truman Dam and Reservoir Project conducted for the U.S. Army Corps of Engineers (Wood, editor 1977; Roper, editor 1980).

The Research

The materials from which the data used in this research derive consisted of the human skeletal remains from prehistoric tumuli[1] excavated in southwestern Missouri (Fig. 1). Mortuary site investigations in the central Osage River Basin have generally been conducted as salvage archeology within three major reservoir areas — the Pomme de Terre, Stockton, and Harry S. Truman (Bradham 1963; Bray 1963a, 1963b; Chapman, et al. 1963; Chapman and Pangborn 1963; Chapman 1963; Falk and Lippincott 1974; Falk 1969; Marshall 1956; McMillan 1968; Pangborn 1965, 1966; Wood 1961, 1967; Wood and Pangborn 1968). Except for the few shelter (Bass and Rhule 1976) and spring site graves (Jeffery Saunders, pers. com.), the tumuli contained all the biological remains currently available from southwest Missouri. A general description of the excavated tumuli within the area is given in Appendix I. Human skeletal material was available from 48 of these (Fig. 2), generating a sample of 302 individuals. Only one tumulus is possibly pre-Woodland as determined from material inclusions (Goldberg 1980).

The 48 tumuli were analyzed as an aggregate. Tumulus-by-tumulus analysis would not provide an answer to the research question posed earlier nor make a meaningful contribution toward the understanding of the culture-history of the area. The sterility of intertumuli comparison is primarily due to the average of only 6.3 individuals per tumulus, the paucity of absolute dates, and the lack of previous systematic investigations lending guiding insight into the range of variability in content and form.

This bioanthropological study was undertaken as part of the five year archeological research project in the Harry S. Truman Dam and Reservoir area contracted by the University of Missouri with the U.S. Army Corps of Engineers. The approaches taken in interpreting the cultural resources of the area were numerous and encompassing. The participation of this investigation in such interdisciplinary research negates the concern of using a specific, single-function site to infer culture-historical processes. Additionally, an analysis of the artifactual assemblages recovered from the burial tumuli (Goldberg 1980) is being undertaken concurrent with this analysis of the human skeletal remains. On a smaller scale

[1]A tumulus is an artificial surface feature composed of earth and/or stone which was built for the purpose of disposal of the dead.

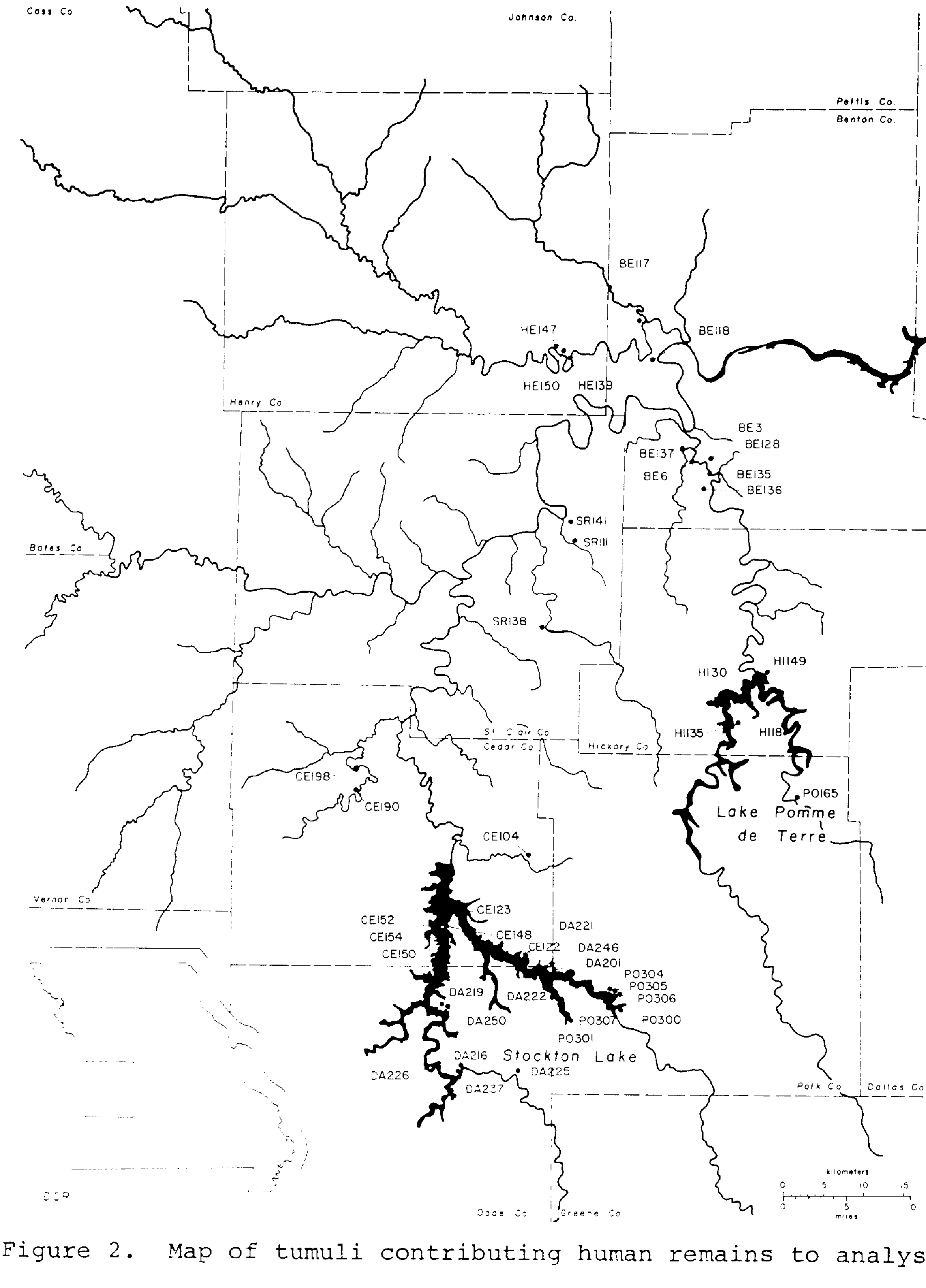

Figure 2. Map of tumuli contributing human remains to analyses.

then, our approach is a conjunctive one (Taylor 1968) to the interpretation of the prehistoric burial program, interarticulating biology, culture and environment.

One final and crucial feature of the research design needs to be elucidated. Corn (maize) was recovered from some but not all of the burial tumuli. The occurrence of corn in an archeological context has been viewed as a milestone in reconstructions of culture history. Implicit with the discovery is a momentum toward changes in the subsistence base, an increase in population density, sedentism, trade, increased potential for and the maintenance of disease, and warfare. At times, such a perspective may be a gross imposition on the archeological data. An avenue of investigation pertinent to an evaluation of the significance of corn in an archeological setting is the biological data, especially the human skeletons. The interaction between human biology and culture is now understood to be a complex, tightly interwoven phenomenon (Alland 1970; Blakely, ed. 1977). Researchers are aware that humans do not and did not exist at a level of isolation and independence, but function as integral parts of a natural and/or human-made biocultural interactive system. Research in the neighboring Lower Illinois Valley aimed at quantifying the transition from Woodland to Mississippian economies, i.e., hunting and gathering to maize horticulture, through the analysis of cemetery populations, have demonstrated significant correlations between subsistence and various quantifiable human biological manifestations (Cook 1975; Cook and Buikstra 1979; Lallo 1973; Perzigian 1977b).

One of the goals set for this research, then, is an evaluation of the significance of corn in prehistoric southwest Missouri. In the analyses to follow, individuals from tumuli containing corn are contrasted with those from tumuli lacking corn. For the purposes of testing the hypothesis advanced in each chapter, it is necessary to assume that tumuli where corn was not recovered indicates non-utilization of the grain. Of course, a failure to reject this hypothesis could be due to incomplete knowledge, i.e., that corn existed but was not recovered or included in the mortuary ceremony, that there were individual differences in susceptibility to the nutritive deficiencies of corn, etc.

The thoroughness required for implementation of the research design dictated the compilation of data from various skeletal sources. Each chapter is designed to be essentially self-contained and devoted to a particular topic. Chapter II presents a descriptive model of the prehistoric demography of southwestern Missouri as determined from the existing skeletal sample. Particular attention is accorded those aspects of the demographic profile which may indicate population or dietary differences and/or nutritional stress within the series. Chapter III discusses the social dimensions

of mortuary practices in southwest Missouri. Evidence for patterned variability in age, sex, and social status are examined through analyses of the dynamics of individual burials. Also, spatial regularities within the study area are determined from similarities in form and content of the burial tumuli. Chapter IV evaluates the dentition and orofacial architecture of a subsample of the prehistoric Missourians, especially emphasizing the rate of attrition, oral pathology, dentofacial metrics, and subsistence. Finally, Chapter V discusses the nature of the development and adaptation of the aboriginal population in the central Osage River Basin Region.

CHAPTER II

DEMOGRAPHY

Introduction

Chapter Orientation

When confronted with a collection of prehistoric human skeletal remains from a spatially defined area but of uncertain or broad temporal affiliation, the first task is to ascertain if the collection constitutes a single population or lineage (see Cadien, Harris, Jones, and Mandarino 1974). The primacy of such an assessment is especially acute in the series from southwestern Missouri where corn, a much abused horizon marker, was not recovered from all of the burial tumuli. The purpose of this chapter can be stated quite simply: to determine if the skeletal series from southwest Missouri represents a single population.

A comparison among individuals from tumuli with corn and individuals from tumuli without corn form the foundation in all approaches taken in this study. These approaches include an evaluation of mortality and of nutritional stress as measured in the frequency of indications of infectious disease and in relative skeletal stature. Further explanation and elaboration of the parameters involved are discussed below.

Demography and Health

"Death. . . is the ultimate response which an organism is capable of making to any given stressful situation" (Lallo 1973: 118). In a given population, the sources or intensities of stress may vary with age, sex, nutritional status, and general health. Variabilities in stress may be reflected in the age-specific mortality patterns of a population. Therefore, before the demographic patterns of a skeletal population can be described and evaluated, accurate determinations of age and sex must be made.

Techniques Used in the Determination of Age and Sex

Accurate age and sex determinations require examination of as much of the skeleton as possible. Generally, the more skeletal parts the greater the accuracy. Processes beyond human control often determine the amount of skeleton available for analysis. Unfortunately, destructive processes were quite evident in southwest Missouri. Activities of natural agents, e.g., soil, pH and moisture, and human agents, e.g., pothunting intrusions and processing practices of the burial

party, often left the skeletal material in a poorly preserved and badly fragmented state. The incompleteness of the skeletons precluded the use of statistical techniques in the assessment of age and sex. The possibility of determining age through histomorphometric analysis of sections of cortical bone was considered (Stout and Teitelbaum 1976a, 1976b; Stout and Simmons 1979). Microscopic examination of a sample of thin sections of undecalcified ribs, however, revealed that the diagenic conditions of the soil precluded histological analysis.

The following is a description of the criteria and techniques employed in the ageing and sexing of individuals from the 48 burial tumuli. Caution was maximally exercised as necessitated by the fragmentary remains. Two sets of observations were made by the author, separated by a one year interval.

Age

Biological age determinations for each individual were based upon the following criteria:

Subadults (0-15 years)

1. Dental eruption patterns (Schour and Massler 1944).
2. Appearance of ossification centers (from Krogman 1962).
3. Epiphyseal closure (from Krogman 1962; Bass 1971).
4. Long bone length (Johnston 1962).

Adults (16-55 years)

1. Development of the third molar (Schour and Massler 1944).
2. Epiphyseal closure (from Krogman 1962).
3. Dental attrition patterns for southwestern Missouri aboriginal population (established by the author).
4. Endocranial suture closure (Neumann 1971).

Based upon the above methods, the age classes used in the analysis were as follows:

Specific divisions:	Child (0-10 years)
	Adolescent (11-15 years)
	Young adult (16-25 years)
	Adult (26-35 years)
	Mid-adult (36-45 years)
	Old adult (46-55 years)
General divisions:	Subadult (0-15 years)
	Adult (16-55 years)

Sex

No attempt was made to sex the subadults as secondary sex characteristics are not developed well enough for accurate assessment. The following methods were used in ascertaining post-adolescent sex:

Subjective:

1. Observations of the bony pelvis (from Krogman 1962; Bass 1971).
2. Cranial morphology (from Krogman 1962; Bass 1971).
3. Comparative robusticity of the long bones.

Metric:

1. Maximum diameter of the head of the humerus (from Krogman 1962).
2. Maximum diameter of the head of the femur (from Krogman 1962).
3. Dental measurements for southwestern Missouri aboriginal population (established by the author).

The age and sex distribution is given in Appendix II. The skeletal metrics (Finnegan 1970) and non-metrics (Buikstra 1976; Finnegan and Faust 1974) compiled during the osteological analysis are given in Appendix III.

Representativeness of the Sample

An important consideration prior to any demographic reconstruction concerns the representativeness of the sample. The possibility of the loss of large numbers of individuals to extra-tumulus mortuary activity must be considered before demographic profiles can be made. After extensive survey and excavation in southwestern Missouri (see Chapter I for references), there is as yet no evidence of unmounded cemeteries and only a single incidence of the disposal of the dead was found in association with a habitation site (Falk 1969). As all burial tumuli were fully excavated it can be safely assumed that a significant proportion of those individuals buried in tumuli were recovered. The subadults may be underreported in a recovered cemetery population (Jaffe and Medina 1979). Probable causes of the underrepresentation include the lack of preservation of the relatively delicate bones and the practice of not giving burial recognition to newborns and young children. Consequently, when the data are suspect, a method of smoothing should be applied to the age distribution curve replacing the missing young (Weiss 1973). The data from southwest Missouri were not smoothed as the percentage of subadults to adults was considered acceptable. Processing of the deceased included burning and secondary interment. The extent of the loss of individuals

through cremation and above ground decomposition is uncertain. However, large quantities of burned and unburned primary elements of the skeleton (i.e., ribs, phalanges, vertebrae, carpals, and tarsals) were scattered throughout each tumulus. Suspicions of the loss of significant numbers of the deceased, therefore, seem groundless. Thus, the individuals available for demographic analysis are here regarded as a representative sample of the prehistoric inhabitants of southwest Missouri.

Another important consideration is whether the skeletal series is representative of a single population or population lineage. Cadien and others (1974) argue against the population analysis approach to archeological skeletal data, as the sample cannot be considered a breeding population as defined by Mayr (1963). They contend that a skeletal series with members having zero probability of mating constitutes a population lineage: ". . . a sample of a temporally ordered sequence of populations, presumably with genetic continuity, . . . " (Cadien and others 1974: 196, emphasis mine). Within the bounds of the population as defined by Mayr, their arguments are just. However, a population may be defined as a spatial-temporal group of inter-breeding individuals; continuity through time is maintained by reproductive interconnections between generations (Mettler and Gregg 1969: 30). Numerous definitions could be cited, but all agree that the individuals composing the skeletal series, or population, share the same gene pool. Archeologically recovered skeletons are rarely restricted to individuals who were alive simultaneously. Thus, the most that can be assumed for purposes of hypothesis testing is genetic similarity. As the time span considered here involves only a few generations, the skeletal series is presumed to be inbred. Thus, the approach taken to the southwest Missouri skeletal series is population analysis; and working within the constructs of stable population theory, the demographic profiles of the southwest Missouri aboriginal population are interpreted.

Nutritional Stress

Disease and pathological processes often go unnoticed in a skeletal series primarily because they are often not grossly evident. Relatively few specific disease processes are identifiable in skeletal remains. The body's response to infectious disease in general, however, may leave a mark on the skeleton.

The bony response to some infections is primarily one of inflammation. The age of the individual, skeletal distribution, and the extent of the inflammation are important variables in differential diagnosis (see Steinbock 1976). Basically, inflammatory diseases can be classified as either periostitis – inflammation of the outer layer of bone with no involvement of the cortex; osteitis – inflammation of

the bone surface and cortex; or osteomyelitis – inflammation of the cortex with involvement of the medullary cavity.

Studies in underdeveloped countries reveal a relationship among subsistence strategies, infectious disease and increased mortality rates, especially of subadults (Bengoa 1959; Scrimshaw 1966). Infectious disease is often precipitated by malnutrition resulting from agricultural practices which provide a high carbohydrate, low-protein diet. The likelihood of contracting infectious disease is especially acute for children of weanling age, 1-4 years (Scrimshaw 1964; Stini 1971). This wasting disease, termed "weanling diarrhea," is a common result of a weanling diet high in carbohydrates and low in protein. A diet consisting predominately of corn can be responsible (Stini 1969).

In the Midwest, the occurrence of pathological lesions of infectious disease has almost become diagnostic of corn agriculture (Cook 1975; Gilbert 1975; Lallo 1973). That is not to imply that agriculture causes infectious disease. Increases in population size and density, loss of mobility, clearing of large expanses of land, and exposure to new types of organisms all contribute to increase the potential for infectious disease (Cockburn 1971; Armelagos and McArdle 1975). In general, it appears that as there is a tendency toward sedentism, food production, and greater reliance upon high carbohydrate, low-protein foods, there will be a corresponding increase in the incidence of infectious disease and in the mortality rate.

Retardation of skeletal growth is another result of poor nutritional health (Garn 1966; Jackson 1966). Quantification of long bone growth and development, and comparison of these data between populations of differing subsistence strategies, have successfully revealed dietary transitions (Cook 1975; Gilbert 1975; Lallo 1973). R. Gilbert (1975) found adult stature to decrease concomitantly with the advent of corn agriculture in three Dickson Mound populations.

The recovery of such a potentially discriminating attribute as corn from some of the tumuli required an investigation of the biological responses to it in southwest Missouri. Based upon the findings of Cook (1975), Gilbert (1975), and Lallo (1973), but tempered by the lack of archeological evidence for agricultural practices, the following predictions will be discussed:

1. From the comparison among southwestern Missouri individuals from tumuli with corn and from tumuli without corn, an increase in infectious disease, in both adult and subadult mortality, and a decrease in stature is predicted for individuals with corn relative to the individuals lacking corn.

2. The mortality data from southwest Missouri are compared with the available data from Illinois populations representing the Late Woodland (LW), the Mississippian-Acculturated Late Woodland (MALW), and the Mississippian (MISS) (Lallo 1973). It is predicted that the southwest Missouri population should reveal a greater similarity to the LW and MALW populations.

Methods

The prehistoric demography of southwestern Missouri and two major parameters are being investigated for differences predicted to be attributed to the consumption of corn: mortality and health. The concept of the life table method will be introduced with a brief historical sketch and the techniques of life table analysis will be described. Next, relative health as measured by the incidence of infectious disease and by stature among individuals with and without corn is considered. Lastly, the statistical techniques used in assessing differences in mortality, pathology and stature are presented.

The Life Table

The advent of demographic archeology (see Hassan 1978) as an approach within archeology has led to the refinement of palaeodemography in anthropological research. Until recently, researchers grappled with theoretical issues arising from criticisms of the use of the life table in reconstructing demographic processes of prehistoric skeletal populations (for criticisms see Angel 1969; Howell-Lee 1971). However, the utility of the life table as a research tool and its suitability for the analysis of mortality in archeological populations has now been demonstrated (see Lallo 1972, 1973; Weiss 1973; Moore and others 1975).

The life table technique used in estimating mortality rates of southwestern Missouri was based on a stationary population model (Acsadi and Nemeskeri 1970). The theoretical assumptions of this approach are: (a) the population was stable, i.e., with fixed rates of mortality and fertility at each age interval, (b) the population experienced no immigration or emigration (Acsadi and Nemeskeri 1970: 61) and, (c) the intrinsic rate of growth equaled zero. Reciprocal immigration does not violate the second assumption (Weiss 1973). The procedures followed in the construction of the life table differed from Acsadi and Nemeskeri (1970) only in the breadth of the age interval. The statistics required were:

1. x - the age interval
2. Dx- the actualnumber of dead individuals in the age interval.
3. dx- The Dx value expressed as a percentage of the total sample.
4. lx- the percentage of the population surviving to each age interval.

5. qx- the probability of dying.
6. Lx- the number of years lived by individuals at each age interval.
7. Tx- the total number of years lived by individuals at or above each age interval.
8. ex- the life expectancy at birth or the years remaining (x) at each age interval.

The demographic data were obtained from the analysis of 302 individuals. Life tables were computed from the age and sex distributions for individuals from tumuli containing corn, for individuals from tumuli lacking corn, and for all individuals combined; mortality was also analyzed from the data generated by the life tables.

Infectious Disease and Stature

The skeletal material employed in the analysis of infectious disease consisted of 302 individuals from southwestern Missouri. All available bone fragments, burned and unburned, were examined macroscopically for indications of inflammation. Dry burning was found to alter the bone surface minimally; pathological lesions were still discernible regardless of charring. Calcined bone fragments suggestive of flesh burning were generally few and quite small. The extent of the bones' surface alteration from total calcination was difficult to determine. However, the endosteum was not adversely affected by the degree of burning, and fragmentation exposing the medullary cavity permitted observation which would have been impossible otherwise. There were no calcined fragments that displayed an endosteal bony response suggestive of infectious disease.

The incidence of infectious disease was quantified by individual rather than by bone. This was done in order to avoid the task of counting all the bone fragments from each tumulus. The minimum number of individuals affected was used in the comparative evaluation.

Fragmentation and breakage precluded the assessment of stature using whole bone methods. Steele (1970) has devised a technique of estimating stature from fragmentary long bones. His technique provides a lineal least squares estimate of the maximum length of the femur, tibia, and humerus from direct measurements of specific sections of the bone. The maximum length value obtained is treated no differently than a whole bone length value, and is applied to the appropriate formulae for the determination of stature. Trotter and Gleser's (1952: Table 13; 1958: Table 12) formulae for White females and Mongoloid males, respectively, were used for stature calculations.

Steele's (1970) method lacks precision; the resultant estimate of height yields a minimum standard deviation of 8.0

cm in the calibrated sample. But, if used exclusively and not compared against height values derived from whole bone formulae, the results should be consistent through the sample. The method was employed upon individuals of known age and sex having the incomplete limb bones.

Statistical Analyses

The mortality data from southwestern Missouri were evaluated in several ways. Initially, the age-specific mortality frequencies (Dx values in the life table) were computed for the group of individuals from tumuli with corn, for the group without corn, and for the combined series. By expressing the values in cumulative frequencies, significant differences could be tested for across the groups. The Kolmogorov-Smirnov Test was employed to test for the differences.

The Kolmogorov-Smirnov Two-Sample Test (Sokal and Rohlf 1969) assesses whether two independent samples share a similar distribution, and indirectly indicates the magnitude of the difference at each interval. The two-tailed test reveals any kind of difference among the samples. When applied to the cumulative distribution of mortality for individuals with and without corn, the test should indicate if a difference in mortality exists between the two groups. As the remaining demographic parameters are a direct function of the age-specific mortality, it follows that differences between the groups would also be evident throughout the life table. Applied to the mortality data divided by sex, the Kolmogorov-Smirnov Test will demonstrate if there is a difference between female and male mortality.

The results of the analysis of mortality data may be interpreted as expressions of biological adaptation of prehistoric southwestern Missourians within a particular cultural milieu. Specifically, the effects of the interaction among nutrition, infectious disease, and growth can be detailed.

The analytical techniques applied to the pathological data and estimates of stature include tests of variance and of significance of bivariate distributions. The student's t-test was computed for the stature data. The t-test examined the difference between means of the groups with corn and without corn. The chi-square (X^2) test of significance was calculated for the incidence of infectious disease. Each test was designed to determine whether significant differences exist between the group of individuals with corn and the group without corn.

Results

In this section, the demography of the prehistoric skeletal series from southwestern Missouri is presented in life table form. Life tables are computed for the group of individuals from tumuli containing corn, from tumuli lacking corn, for the combined series, and for the females and males of the combined series. The mortality frequencies from the life tables are described and the following comparisons are made:

1. Southwestern Missouri: Individuals with corn and individuals without corn.
2. Southwestern Missouri and Illinois populations.
3. Southwestern Missouri: Female and male mortality.

Lastly, the results of the analysis of infectious disease and stature are presented.

Mortality

Mortality data were derived from the life tables computed for the subgroups and for the southwest Missouri population (Tables 1, 2, and 3). Values of sampling error for the combined series are provided in Table 4. A perusal of the values in all three life tables reveals some interesting features. There is not a consistent underlying trend in the dx values (age-specific mortality) and qx values (probability of dying) for the age classes. A great amount of variability is especially evident at the 16-25 year old interval. A spurt in the qx value occurs consistently in all groups for the 26-35 year olds. This upsurge in adult mortality may in part reflect the inability to accurately age a sizeable proportion of the skeletons approximating adulthood. Such individuals were given the mean adult age, 35 years, which created an over-abundance in the 26-35 year old interval. Interestingly, the lx value (survivorship) is lower for the 25 year old and younger age classes for the individuals with corn. Subadults with corn were also dying at a younger age. However, the adults reveal greater longevity when compared to adults lacking corn and to the combined series (Tables 5 and 6).

Southwestern Missouri: Individuals With Corn and Without Corn

Survivorship and probability of dying are graphically presented in Figures 3 and 4. The curves outline the differences in the demographic parameters between the group of individuals from tumuli containing corn and the group from tumuli lacking corn. The figures indicate a better chance of survival for subadults without corn and for adults with corn; the over-all probability of dying is less for individuals with corn if they survive the first 10-15 years of life.

When the cumulative frequencies of mortality are graphed (Fig. 5) and compared, the higher subadult mortality for individuals with corn is noted. The Kolmogorov-Smirnov two-tailed test (Table 7) indicates however that the overall trends observed between the groups are not significant ($p>.05$). Thus, the groups have a 5% probability of not belonging to the same population. However, the differences in mortality are still worth noting for future tumuli excavations and research using an enlarged skeletal sample may confirm the hypotheses here. The magnitude of the difference between the cumulative frequencies is greatest in the young adult inclusive (0-25 years) segment of the series; the observed differences between subadults (0-15 years) favors the survival of the individuals without corn whereas the young adults (16-25 years) of this group show a higher death rate than the individuals with corn of comparable age. This odd change in mortality events between the two groups is succinctly displayed in the graph of age-specific mortality (Fig. 6). The higher mortality of subadults, especially the 0-5 year olds, within the group with corn (24% as opposed to 18%) may be reflective of the synergistic effects of malnutrition and infectious disease. The surge of mortality in the young adult segment of the individuals lacking corn may be interpreted as an attempt by the people to increase their numbers by advancing the age of marriage to the early teens. Subsequently, women would be exposed to the hazards of child bearing at an earlier age resulting in the peak period of female mortality to occur during the late teens and early twenties rather than the late twenties and early thirties.

Southwest Missouri and Illinois Populations

Until the late twenties and early thirties, the southwest Missouri survivorship curve closely approximates that of the Illinois Woodland populations (Fig. 7). During the mid- to late twenties, the probability of death sky-rockets to a level exceeding that of the Illinois Mississippian (Fig. 8), abates somewhat during the early thirties before resuming a gradual climb to old age. As indicated previously, the adult age classes may be distorted somewhat as a mean score was applied to adults of indeterminate age. However, the close approximation of the southwestern Missouri data with the Illinois Woodland is relevant in the lower age groups where biological ageing criteria are most reliable. Underrepresentation of individuals due to poor preservation (Weiss 1973; Jaffe and Medina 1979) is a problem with the lower age classes. But, the percentage of subadults to adults in both subgroups and for the combined series (36%) is close to the 40% considered acceptable (Table 8). A comparison of the cumulative frequency graph of mortality (Fig. 9) reveals the southwestern Missouri young adults profile to be strikingly similar to that of the Illinois Woodland. However, the life expectancy figures (Table 9) are quite dissimilar.

TABLE 1

Life Table for Individuals From Tumuli With Corn

x	Dx	dx	lx	qx	Lx	Tx	ex
0-5	30	24.0	100	.240	440	2186	21.9
6-10	12	9.6	76	.126	356	1746	23.0
11-15	7	5.6	66.4	.084	318	1390	20.9
16-25	11	8.8	60.8	.145	564	1072	17.6
26-35	44(8)+	35.2	52.0	.677	344	508	9.8
36-45	11	8.8	16.8	.524	124	164	9.8
46-55	10	8.0	8.0	1.00	40	40	5.0
TOTAL	125	100	0.0				

TABLE 2

Life Table for Individuals From Tumuli Without Corn

x	Dx	dx	lx	qx	Lx	Tx	ex
0-5	32	18.1	100	.181	454.8	2174.3	21.7
6-10	20	11.3	81.9	.138	381.3	1719.6	21.0
11-15	8	4.5	70.6	.064	341.8	1338.3	19.0
16-25	34	19.2	66.1	.290	565.0	996.6	15.1
26-35	58(11)+	32.8	46.9	.699	305.0	431.6	9.2
36-45	15	8.5	14.1	.603	98.5	126.5	9.0
45-55	10	5.6	5.6	1.00	28	28	5.0
TOTAL	177	100	0.0				

+Number in () indicates those individuals of known age.

TABLE 3

Life Table for Southwest Missouri

Age	Deaths		Survivors	Probability of Death	Total Yrs. Lived For X	Total Yrs. To Be Lived	Life Expectancy
x	Dx	dx	lx	qx	Lx	Tx	ex
0-5	62	20.5	100	.205	448.3	2178.8	22.0
6-10	32	10.6	79.5	.133	371.0	1730.5	22.0
11-15	15	5.0	68.9	.073	332.0	1359.5	19.7
16-25	45	14.9	63.9	.233	564.5	1027.5	16.1
26-35	102	33.8	49.0	.690	321.0	463.0	9.4
36-45	26	8.6	15.2	.566	109.0	142.0	9.3
46-55	20	6.6	6.6	1.0	33.0	33.0	5.0
TOTAL	302	100	0.0				

TABLE 4

Mean Age and Standard Error For Each Interval (D_x)

Age Interval	$\bar{X}$ Age	S.D.
0-5	2.1	1.271
6-10	7.7	1.262
11-15	12.6	1.361
16-25	21.3	3.139
26-35	34.0	2.288
36-45	41.4	2.843
46-55	47.9	1.721

TABLE 5

Summary of Vital Statistics for Individuals With and Without Corn

	Mean Age at Death in Years	
	With Corn	Without Corn
Total Series	22.2	22.2
Subadults (0-15 yrs.)	5.3	5.7
Adults (16-55 yrs.)	33.1	30.6
Adults of known age	35.5	30.6

TABLE 6

Summary of the Vital Statistics for Southwest Missouri

	Mean Age at Death in Years
Total population	22.2
Subadults Age 0-15	5.6
Adults Age 16-55	31.6
Adult females	30.7
Adult males	35.1

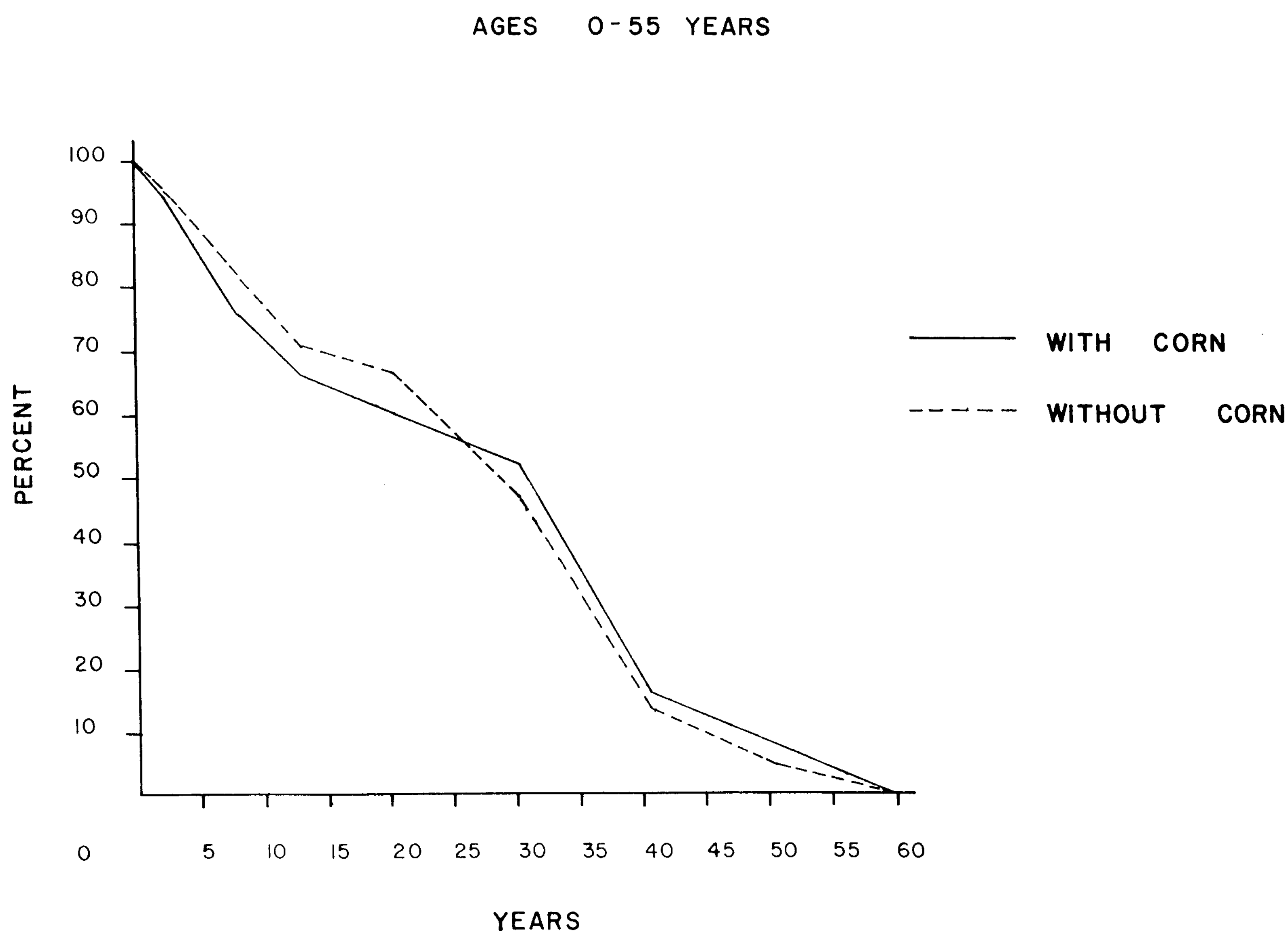

Figure 3. The survivorship curve for individuals from tumuli with corn and tumuli without corn.

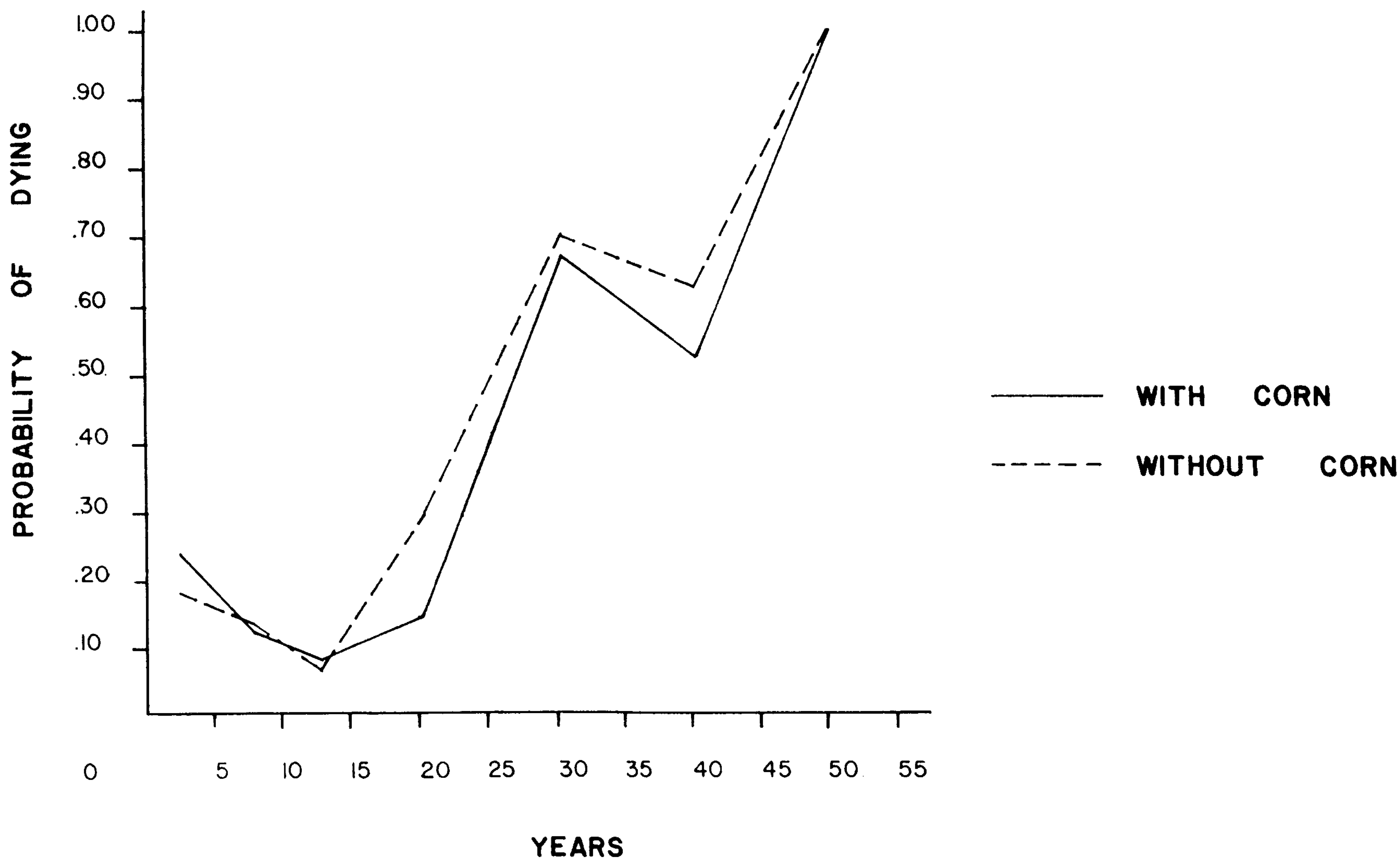

Figure 4. The probability of dying for individuals from tumuli with corn and tumuli without corn.

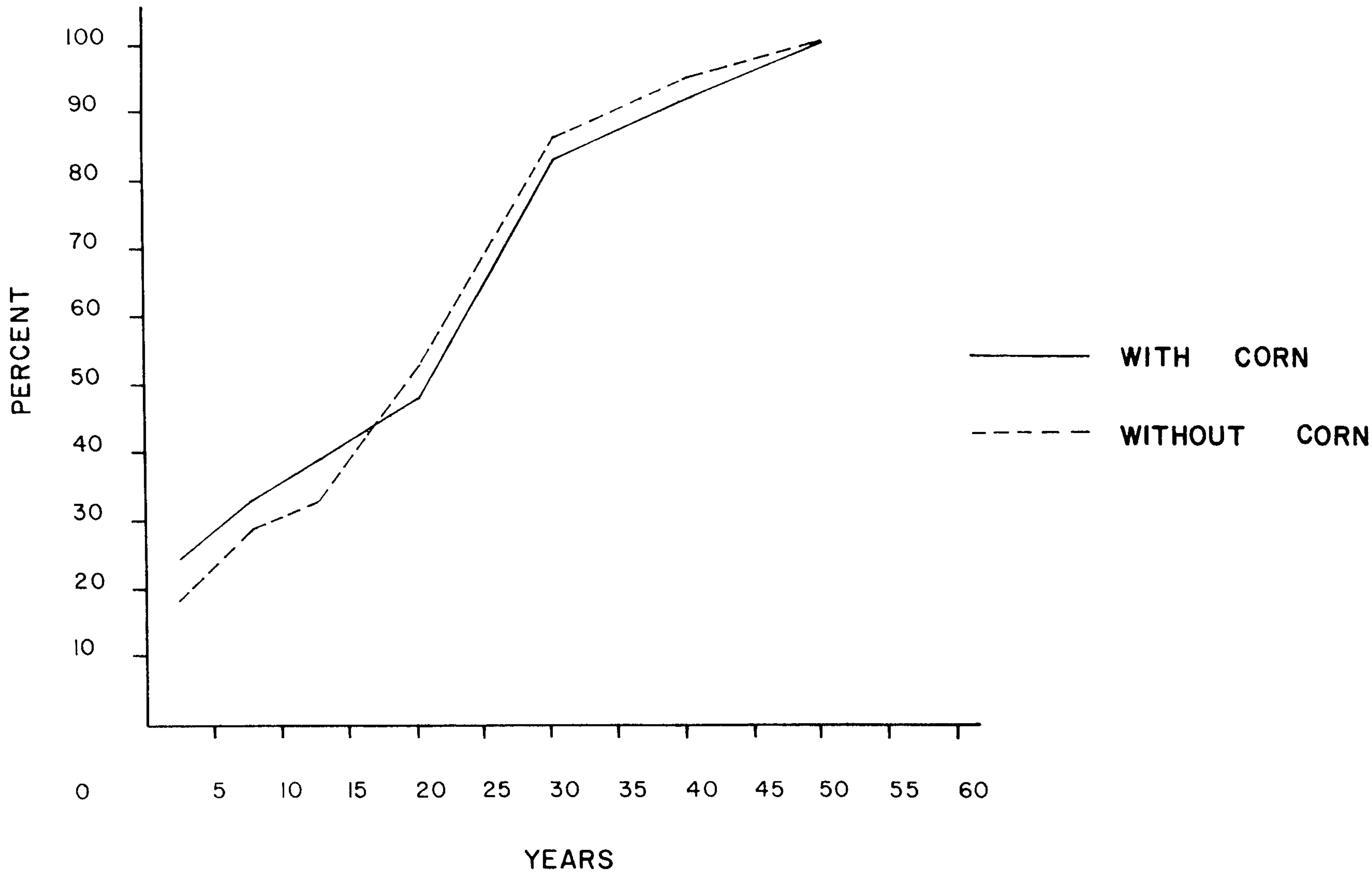

Figure 5. Cumulative percentage of mortality for individuals from tumuli with corn and tumuli without corn.

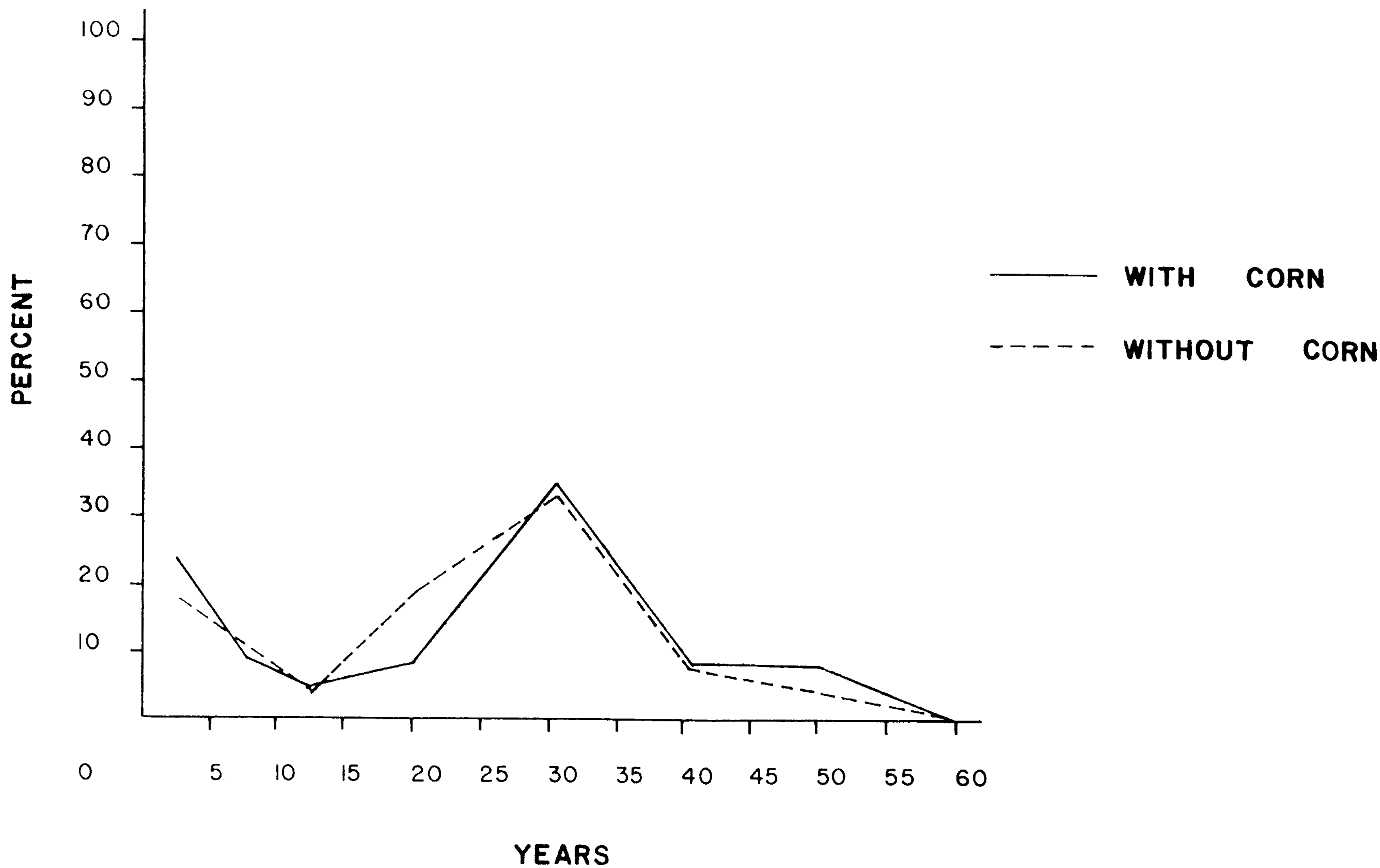

Figure 6. Age-specific mortality rate for individuals from tumuli with corn and tumuli without corn.

TABLE 7

Results of the Kolmogorov-Smirnov Two-Tailed Test For Individuals With and Without Corn

Age	Cumulative % of Mortality With Corn	Difference	Cumulative % of Mortality Without Corn
6-10	33.6	4.3	29.3
11-15	39.2	5.3[+]	33.9
16-25	48.0	5.7	53.1
26-35	83.2	2.7	85.9
36-45	92.0	2.4	94.4
46-55	100.0	0	100.00
TOTAL	125		177

[+]Denotes the largest difference between the groups.

D = .0530

p .05 = .1589

p > .05

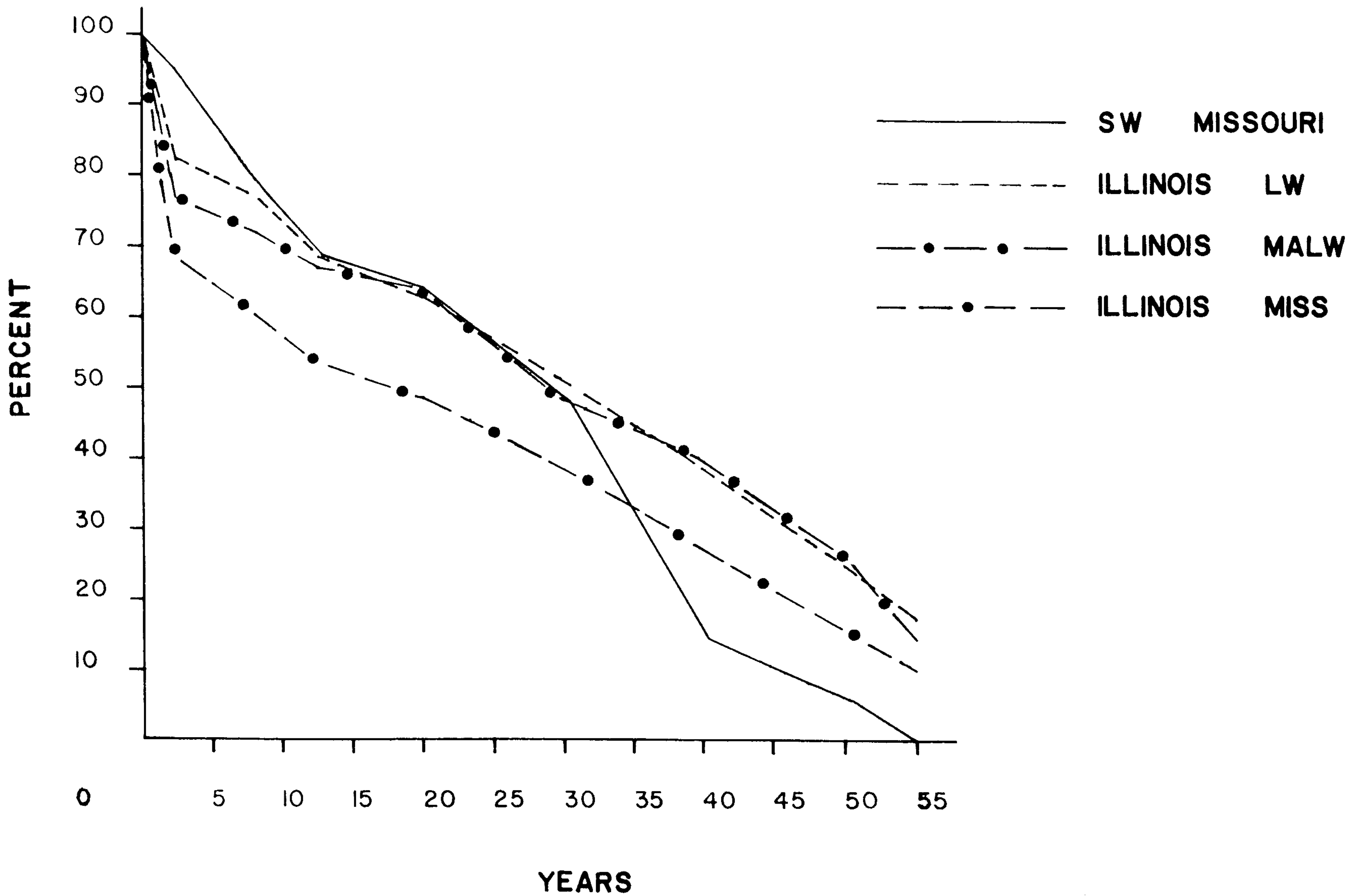

Figure 7. The survivorship curve for southwest Missouri, the Illinois Late Woodland, Mississippian-Acculturated Late Woodland, and Mississippian.

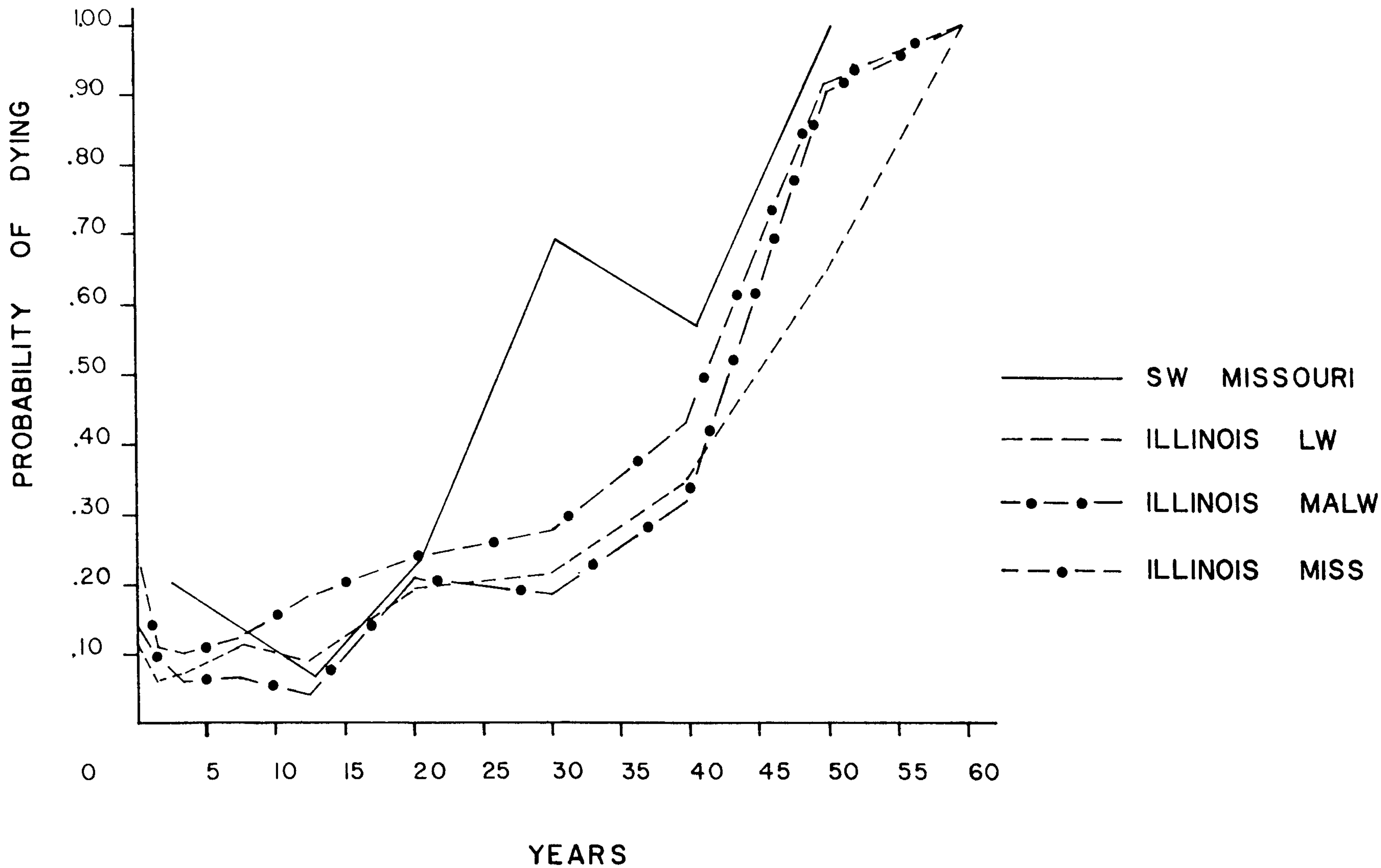

Figure 8. The probability of dying for southwest Missouri, the Illinois Late Woodland, Mississippian-Acculturated Late Woodland, and Mississippian.

TABLE 8

Summary Distribution of Skeletons From Southwest Missouri

	Entire Sample	With Corn	Without Corn
Total Series			
Subadults	109 (36.1%)	49 (39.2%)	60 (33.9%)
Adults	193 (63.9%)	76 (60.8%)	117 (66.1%)
Females	52 (26.9%)	25 (32.8%)	27 (23.1%)
Males	57 (29.5%)	27 (35.5%)	30 (25.6%)
Sex unknown	84 (43.5%)	24 (31.6%)	60 (51.3%)
Sexable			
Sex known	109 (56.5%)	52 (68.4%)	57 (48.7%)
Females	52 (47.7%)	25 (48.1%)	27 (47.4%)
Males	57 (52.3%)	27 (51.9%)	30 (52.6%)

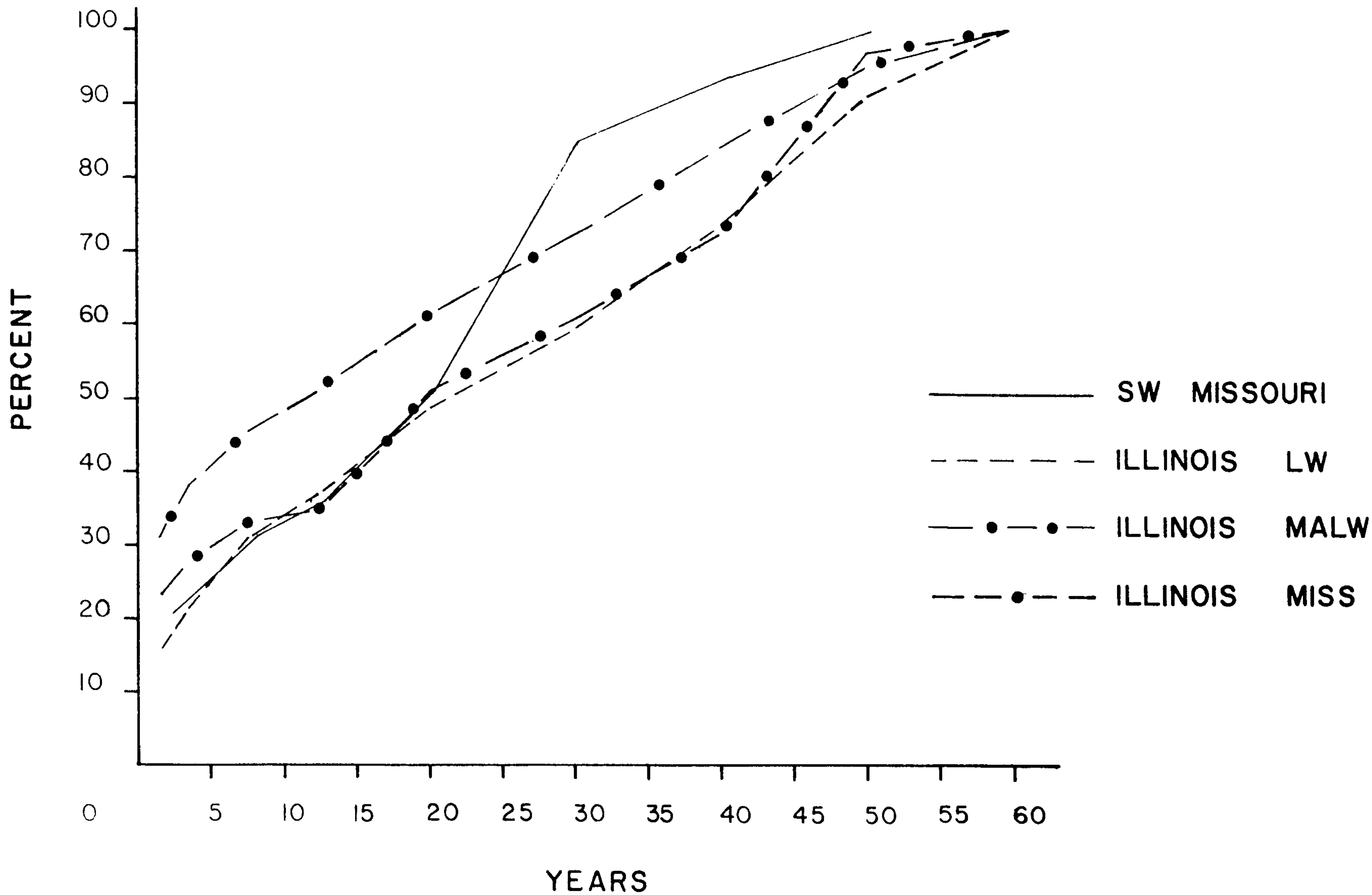

Figure 9. Cumulative percentage of mortality for southwest Missouri, the Illinois Late Woodland, Mississippian-Acculturated Late Woodland, and Mississippian.

TABLE 9

Summary of the Life Expectancy (ex) for Southwest Missouri, the Illinois Late Woodland, Mississippian-Acculturated Late Woodland and Mississippian*

Interval (Years)	Mid Point	SW Mo.	Ill. LW	Ill. MALW	Ill. Miss.
0-5	2.5	22	51	51	43
6-10	8	22	40	40	36
11-15	13	20	32	32	30
16-25	20.5	16	25	24	23
26-35	30.5	9	20	20	17
36-45	40.5	9	14	12	12
46-55	50.5	5	8	6	8

*Adapted from J. Lallo (1973) Table 21: 135.

Southwest Missouri falls consistently below values for the Illinois populations (adapted from Lallo 1973: Table 21), suggesting a much lower standard of living within the Ozark Highland.

Southwest Missouri: A Comparison of Female and Male Mortality

The introduction of sex as one of the variables allows the comparison of adult female and male mortality. Inferences could not be made regarding sex ratio differences within and between the subgroups of individuals with and without corn as the sample sizes were too small to be meaningful. As sex determinations were not made on subadults, information is not available concerning differential sex mortality during the initial 15 years of life. The life tables for the adult females and males from southwestern Missouri are given in Tables 10 and 11.

When the age-specific mortality frequencies are graphed for adult females and males of known sex (Fig. 10), different distributions to mortality become evident. Females seem to be dying at a younger age; the peak period of death occurring during the late twenties and early thirties. This peak is followed by a precipitous drop in mortality then a leveling off far below that of the males. Male mortality never actually peaks but reaches a plateau spanning a 10 year period beginning in the early thirties. A gradual, steady decline characterizes old age with proportionately more men dying than women. The mortality patterns observed here are typical of most human populations (Acsadi and Nemeskeri 1970).

In graphing the cumulative frequencies of mortality for adults of known sex (Fig. 11), it is observed that mortality frequencies are much higher for females than for males. This trend, again a common finding, begins in early adulthood and persists throughout the entire life-span. The difference is most acute between the ages of 25-35 years. The Kolmogorov-Smirnov test (Table 12) indicates that the differences between female and male mortality are significant ($p<.05$). This significant difference may be the result of sampling. However, the differential death rates between the sexes documented here for southwest Missouri are in agreement with mortality events recorded for various other prehistoric and living human populations (Acsadi and Nemeskeri 1970; Weiss 1973).

Infectious Disease and Stature

It has been suggested that the consumption of corn, a high carbohydrate, low-protein food, and the implications of horticultural activity may lead to an increase in the incidence of infectious disease and a retardation of growth

TABLE 10

Life Table for Southwest Missouri Females

x	Dx	dx	lx	qx	Lx	Tx	ex
16-25	16	30.8	100	.308	846	1518.0	15.2
26-35	25	48.1	69.2	.695	451.5	672.0	9.7
36-45	5	9.6	21.1	.455	163.0	220.5	10.5
46-55	6	11.5	11.5	1.0	57.5	57.5	5.0
TOTAL	52	100.0	0.0				

TABLE 11

Life Table for Southwest Missouri Males

x	Dx	dx	lx	qx	Lx	Tx	ex
16-25	12	21.1	100	.211	894.5	1990.0	19.9
26-35	17	29.8	78.9	.378	640.0	1095.5	13.9
36-45	16	28.1	49.1	.572	350.5	455.5	9.3
46-55	12	21.1	21.0	1.0	105.0	105.0	5.0
TOTAL	57	100.0	0.1				

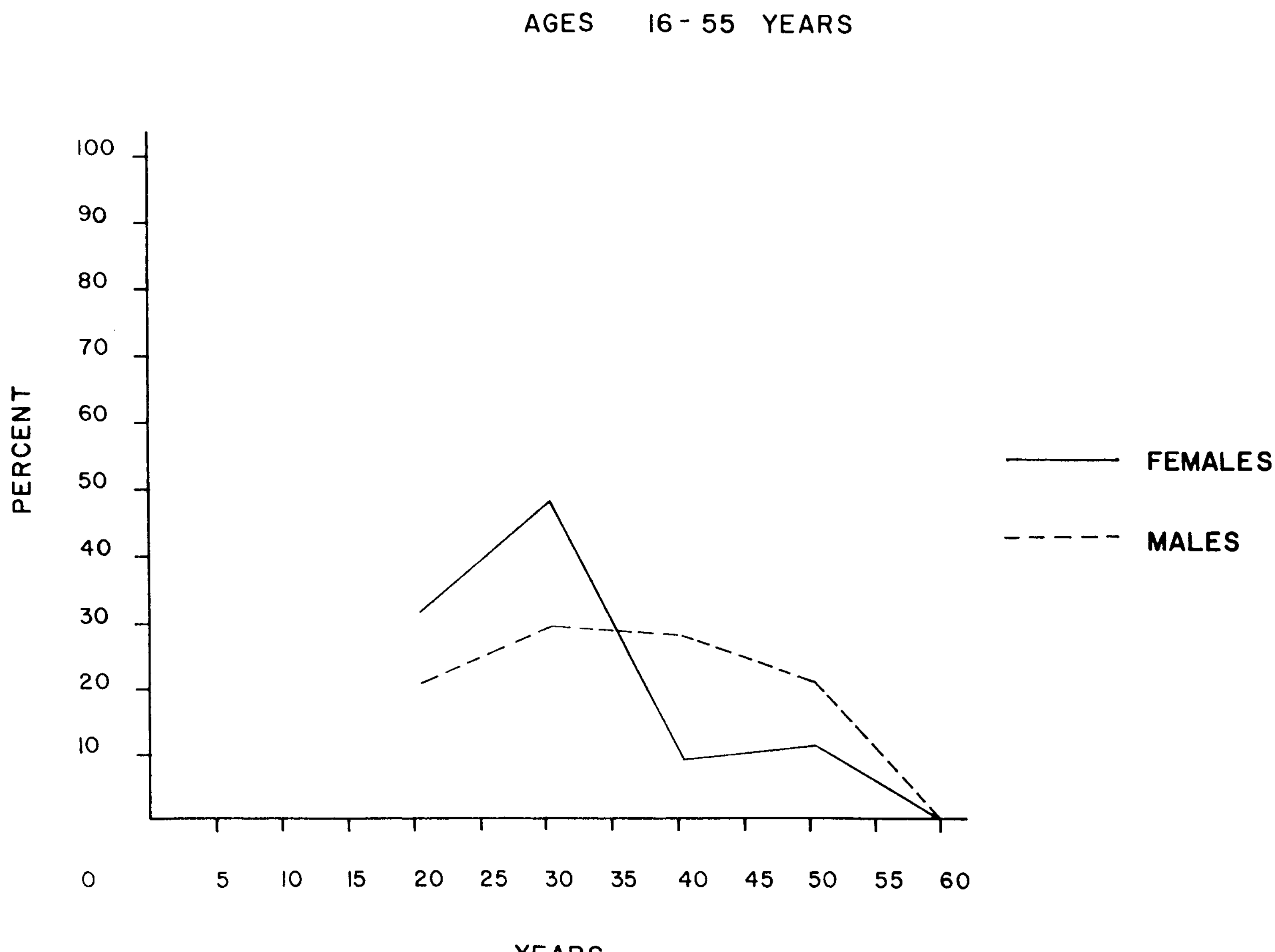

Figure 10. Age-specific mortality rate for females and males of known sex.

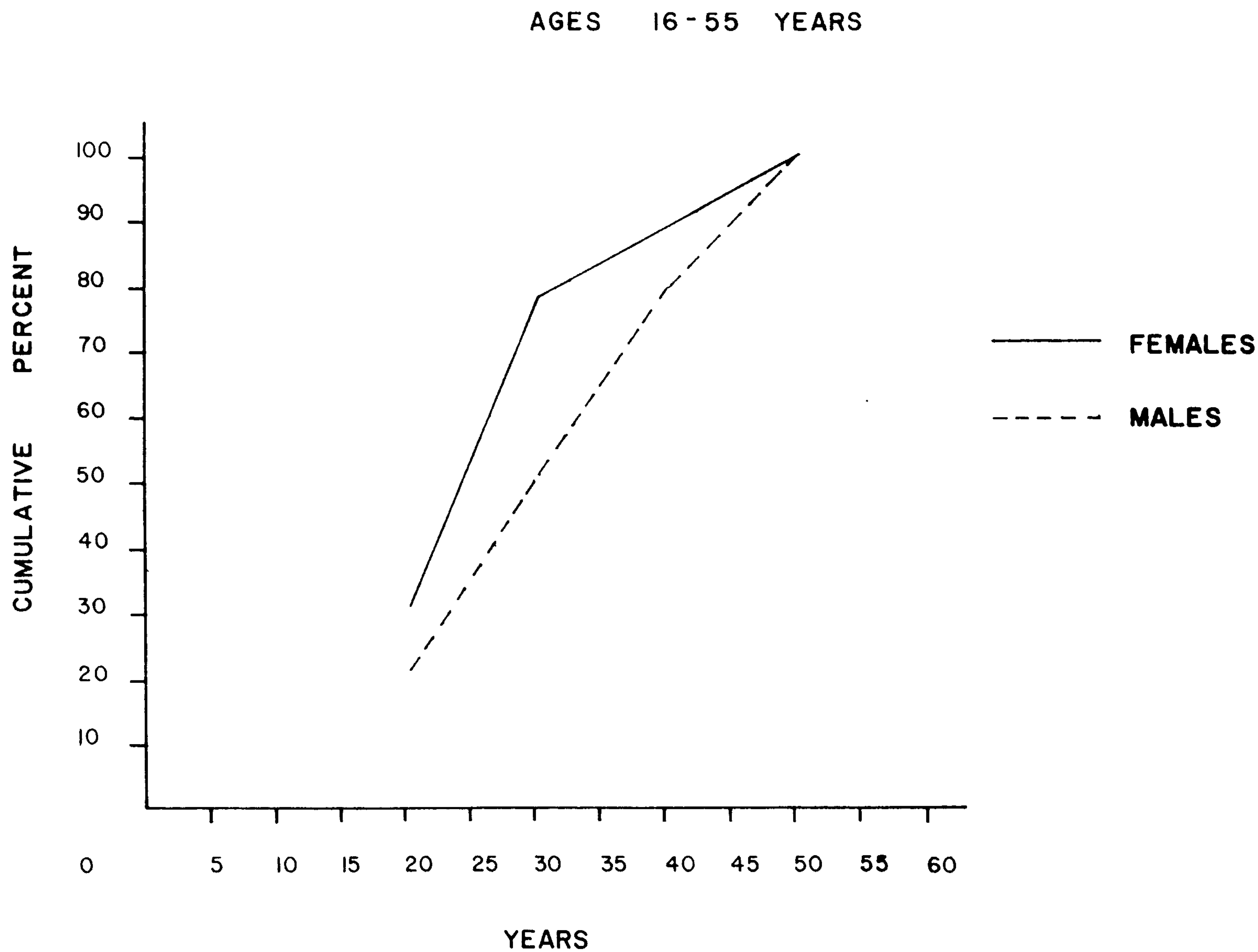

Figure 11. Cumulative percentage of mortality for females and males of known sex.

TABLE 12

Results of the Kolmogorov-Smirnov
Two-Tailed Test for Females and Males

Age	Cumulative % of Mortality Females	Difference	Cumulative % of Mortality Males
16-25	30.8	9.7	21.4
26-35	78.9	27.9+	50.9
36-45	88.5	9.6	78.9
46-55	100.0	0.0	100.0
TOTAL	52		57

+Denotes the largest difference between the sexes.

D = .2790

p .05 = .2608

$p < .05$

TABLE 13

Results of Student's t-Test on Stature

	Without Corn	With Corn
$\bar{X}$ Female	163.82 ± 9.9 cm (11)+	163.54 ± 9.9 cm (9)
$\bar{X}$ Male	163.77 ± 9.65 cm (23)	168.05 ± 9.65 cm (18)
t-test		
Females	.0638, df = 18 p > .10	
Males	.0761, df = 22 p > .10	
Total	.2394, df = 39 p > .10	

+() indicates sample size

in a skeletal series. The southwest Missouri skeletal material is suitable to a test of these propositions as corn was recovered from 11 of the 48 tumuli from which human remains were available.

The macroscopic examination of the skeletal material revealed 15 (8.5%) of the 177 individuals without corn to be pathological and 20 (16.0%) of the 125 individuals with corn to have suffered bone inflammation. A chi-square test of the distribution exceeded the critical value for significance at the .05 level (X^2=4.037), suggesting that the probability is less than 1 in 20 that the difference could appear by chance.

A student's t-test of the difference in the means was computed for the predicted stature (Table 13). The results indicate there is not a significant difference in stature between individuals with corn and those without. These results are not decisive, however, as the method used (Steele 1970) may not be capable of the fine differentiation needed. Imperfect part-whole correlation leads such estimations to approach the mean so that it is a conservative procedure.

Discussion

Initially, the skeletal series available from prehistoric burial tumuli in southwestern Missouri were found to be a sample from a single population. Subdividing the series into individuals from tumuli containing corn and individuals from tumuli lacking corn provided an opportunity to assess the biological significance of corn. The biological parameters of mortality, pathology, and stature were estimated to evaluate the impact of this cultigen. It was predicted that individuals consuming the grain would reveal increased mortality, especially the subadults, greater incidence of infectious disease, and shorter stature relative to individuals not utilizing corn. These predictions were generated from archeological examples where corn supplanted other foods.

A note of caution is needed in interpreting the mortality data. In small samples, changes in mortality frequency distributions cannot unhesitatingly be attributed to cultural and biological processes (Moore and others 1975). In this regard, the demographic characteristics of southwest Missouri described above as well as the following summary can only be considered tentative; a larger sample is required to help mitigate stochastic influences.

Regarding mortality, it was predicted that within southwestern Missouri, individuals from tumuli containing corn would reveal a higher rate of mortality, especially in the

subadult (0-15 years) segment, relative to the individuals from tumuli lacking corn; and it was theorized that the population profiles would be more similar to Illinois Woodland populations than to the Illinois Mississippian population. Although the differences in mortality between the groups with and without corn were not significant, individuals with corn were more apt to die before reaching adulthood than were individuals lacking corn. Upon attaining adulthood, however, the situation reversed, with adults with corn having a better chance of living than those without corn.

In general, the adult sex-specific mortality data replicates the common finding of greater male mortality at all age intervals except the late twenties and early thirties. During those years, female deaths exceed males, a feature typically attributed to complications associated with childbearing.

Southwestern Missouri mortality frequencies for young adults closely approximated those of the Illinois Late Woodland. The greatest divergence occurred at the 0-5 year old interval where preservation differences and cultural variation in disposal of newborns are likely to be most significant. Adult mortality from southwest Missouri could not be equated with any of the Illinois populations compared. Also, the life expectancy figures revealed a much shorter lifespan for the Missourians. Interpolating the life expectancy value for southwestern Missouri (Table 9) at age 15 (E_{15}) and comparing this value with the average values and ranges of the E_{15} for Proto-Agricultural and Hunter-Gathering groups (Weiss 1973: 49) yields the following:

	Southwest Missouri	Proto-Agriculturalist	Hunter-Gatherer
E_{15} =	18	19.8	16.5
Range =		15-28.7	15-19.1

The similarity of the southwest Missouri value to the Proto-Agriculturalist is not surprising as farming tendencies are in evidence.

Significantly more individuals with corn experienced infectious disease, yet a 16.0% infection rate does not denote a rampancy. The data regarding stature were inconclusive. Steele's (1970) technique may not be sensitive to the nuances in individual variation requisite in the manipulation of intra-population height values.

The data seem not to support a reliance upon corn but do differentiate between consumers and non-consumers. The mortality phenomenon can be explained by considering corn as a dietary <u>supplement</u>. The higher percentage of subadult

deaths, especially those younger than five years, and of the group with corn may be a result of a nutritional deficiency. The diet of the young may have been less diverse than the adults, or perhaps the young were given most of what was perceived as the best food item. At times, a corn cake could indubitably have been a most convenient pacifier. The important point is that for the subadults corn may have supplemented their diet to a degree that was detrimental to their general health. The adults, on the other hand, found corn a beneficial, caloric enrichment. Potential deficiencies were alleviated by other resources from hunting and collecting activities.

This argument contradicts that of others (i.e., Armelagos and McArdle 1975; Hassan 1973; Stini 1971) who associate increased survival of weanling age children with agricultural foods. While their position is undeniable in populations with a full agricultural economy, there is evidence that populations in transition experience nutritional deficiencies and increased mortality from infectious diseases (Gilbert 1975; Lallo 1973).

Although the explanation advanced above is tentative and opposite to current views, it is congruent with the available evidence. The inability of mortality differences to show significance confers upon the groups a degree of biological similarity that would not be expected if corn were a dietary staple of one group. The fact that corn was differentially recovered from tumuli in southwestern Missouri, and that individuals from these tumuli express biological characteristics differing in magnitude from the others, demands an explanation beyond a simple all or nothing. The explanation offered here focuses upon a supplement of corn to a previously existing subsistence strategy; a strategy which was not abandoned when horticultural activities began or were intensified.

Implicit in this statement is a temporal difference or lack of co-evality between and among the groups. Presently, the chronologic placement of the tumuli are founded upon techniques of relative dating. Thermoluminscence dates derived from burned artifacts and from human bone from the tumuli are currently being processed. The artifact inventory from the tumuli indicates the presence of a Woodland and a Mississippian component although the effects of cultural continuity tend to minimize this distinction (Goldberg 1980). Interestingly, not all "Mississippian" (artifactual-content classification only) tumuli contained corn and several "Woodland" tumuli did contain corn. When a Kolmogorov-Smirnov two-tailed test was computed from the cumulative mortality frequencies of "Mississippian" plus corn and "Woodland" plus no corn individuals, the results were not significant ($p>.10$). Thus, a temporal <u>separation</u> cannot be

demonstrated from mortuary data pertinent to southwestern Missouri. The continuity is in accordance with the results disclosed in this chapter and will be further substantiated in the chapters to follow.

CHAPTER III

BURIAL DYNAMICS

Introduction

Chapter Orientation

The demographic parameters of the population have been described. Thus, it is possible to interrelate the age and sex of an individual with the preparation and processing of its body and with the form and placement of its grave within the tumulus. Also, tumulus construction is an analyzable artifact of human behavior. In this chapter, the specific attributes of each individual burial (e.g., age, sex, body preparation, etc.), are associated with the structural features of the tumulus (e.g., masonry chamber, burial pits, burned artifacts, etc.); and, the generalized burial types (e.g., extended, flexed/semi-flexed, bundle, etc.), in association with tumuli features may reveal patterns overshadowed by the individual grave elaboration. Thus, three sources of possibly interrelated mortuary data are analyzed: Individual Bodies, Burial Types, and Tumuli Features.

The totality of the attributes from these sources constitute the burial dynamics; their comparison among and between the tumuli comprise the study of mortuary practices. An evaluation of mortuary practices within an area has the potential of revealing aspects of social life and community organization possibly not discernible through a limited open-site archeological record. This chapter details the mortuary practices of southwestern Missouri as determined from analyses of the burial record. Aspects of social organization which may be deduced from mortuary behavior are then generated. Finally, tumuli are grouped together on the basis of the similarities that emerged from the analyses to ascertain a spatial and/or temporal patterning of like tumuli.

Approaches to the Study of Mortuary Practices

Human burials are cultural phenomena. The act of burial, or mortuary practice, involves at least the technical and symbolic spheres of human behavior (Binford 1971). Technically, mortuary activity involves methods of corpse disposal which may include aspects of cemetery construction. Symbolism, a more ephemeral feature, revolves around ritual and the conceptualization of recipient objects (the "referent" of Binford 1971). The referent comprises a deceased individual and all forms of recognition accorded to that

individual via inhumation procedures. The mortuary expression of such identities is analogous to the "social persona" familarized by A. Saxe (1970), and includes both spheres of recognition.

Both the technical and symbolic spheres can contribute to the understanding of a socio-cultural system. Binford (1971), using an ethnographic sample representing four classes of societal complexity – hunters and gatherers, shifting agriculturalists, settled agriculturalists, and pastoralists – demonstrated that elaboration of mortuary behavior varies directly with social organizational features. He concludes (1971: 23):

> . . . the form and structure which characterize the mortuary practices of any society are conditioned by the form and complexity of the organizational characteristics of the society itself.

Archeological studies exploring social dimensions from disposal of the dead practices are numerous. The majority have concentrated upon the symbolic sphere by using grave associations as the primary source of social information (Peebles 1971, Rathje 1970; Rothschild 1979). Tainter (1978), citing an unpublished manuscript (Tainter 1974), argues against the exclusive use of mortuary associations in reconstructions of social relationships. He states that in an ethnographic survey of 93 societies, less than 5% used material inclusions to signify social distinctions. Sole or primary reliance upon artifactual associations is a decidedly limiting methodology.

A research design encompassing the technical dimensions of structural and interment dynamics (i.e., cemetery modifications and burial attributes) and the symbolic dimensions of the archeological inventory (i.e., artifactual grave and/or cemetery inclusions) has proven to be a meaningful form of analysis (see Buikstra 1972; Vehik 1975). Such complementation exemplifies Taylor's (1964) elusive dream – the conjunctive approach which has been adopted here. This chapter considers the technical dimension of the mortuary activity expanded to include the biological characteristics of each human burial. This analysis will be interdigitated in a later report with the archeological constructs analysis of mortuary behavior being undertaken concurrently (Goldberg 1980). In this way, a full picture of the prehistoric burial program can be detailed for southwestern Missouri.

Methods and Results

To facilitate a cohesive presentation of the mortuary data, this section will be subdivided into Individual Bodies, Burial Types, Tumuli Features, and Tumuli Co-Occurrence.

Each analysis is discussed separately, as a unit, with the results immediately proceeding the explanation of the method used. Of these analyses, only the first considers the individual burial; all the others use the tumulus as the unit of analysis. The sample, the attributes and variables evaluated, the statistics, and the results will be detailed for each separate analysis.

Individual Bodies

1. Methods

The entire skeletal series currently available from the southwest Missouri prehistoric burial tumuli were used in the analysis. This consisted of 302 individuals from 48 tumuli (see Appendix II). Table 14 lists the attributes and the associated states scored for each burial.[2] The scoring procedure employed was the non-additive, multi-state technique with 0 denoting an absence, 1 a presence, and 2 a no comparison (Sneath and Sokal 1973: 150-151). A double or run of two's indicated an unknown. In the cluster analysis, negative matches were ignored to prevent the formation of clusters based upon a lack of certain variables. The method of coding and scoring the data resulted in age being weighted six times as heavy as the other states.

The data set Individual Bodies was subjected to multivariate statistical procedures and tests of significance of bivariate frequency distributions were computed. The multivariate procedures will be presented prior to a discussion of the bivariate tests.

A single multivariate technique evaluated the data three ways. Two involved the attributes of each burial and were prerequisite to the formation of the data set used in the third which considered each tumulus. Procedures used in the two analyses of each individual burial will be detailed first followed by a discussion of the tumuli analysis created from the data of the former.

A Q-mode cluster analysis (Program TAXON of NTSYS, Rohlf and others 1972) was used to evaluate the data. The row-standardized data were clustered using the unweighted pair-group method using arithmetic averages. Jaccard's similarity coefficient was employed in measuring the similarity between the burials.

In this research, cluster analysis of individual burials was performed twice, each with a different approach.

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[2]Throughout this chapter, attributes and associated variables will be enclosed in 'tic' (') marks. Further, the attributes will be capitalized while the states will remain lower case.

TABLE 14

Attributes and States of the Individual Bodies Used in the Analysis

Attribute	State
Sex	Female, male, indeterminate.
Age	Child (0-10 yrs.), adolescent (11-15 yrs.), young adult (16-25 yrs.), adult (26-35 yrs.), mid-adult (36-45 yrs.), old adult (46-55 yrs.).
Body preparation	Articulated, rearticulated, bundle, primary remains, broadcast, concentrated broadcast, ossuary.
Burning	Unburned, burned.
Provenience:	
Not central	Original surface, mound fill, crevice, superimposed, chamber, pit.
Central	Original surface, mound fill, superimposed, chamber, pit, pit within a chamber, superimposed within a chamber.
Multiple Burials:	
Double	With a female; with a male; with a child.
Triple	With a female and child; with a male and child; with a female and male; with 2 children.
3 or more	With 2 males and a child (+); with a female, a male, and a child; with 2 males, a female (and a child); with a female and children; with a male and children; with a female, a male and children.

Initially, all attributes contributed to the formation of the clusters. For clarity, this analysis will be referred to as Cluster Analysis-A (CA-A) and the second will be Cluster Analysis-B (CA-B). By omitting the attributes of age and sex, CA-B is hypothesized to disclose a measure of the ability of the other attributes to form socially meaningful groups.

The third analysis began with the results of CA-A. Each tumulus was coded for the presence or absence of individuals falling within the clusters formed from CA-A. For example, 23BE6/1 had individuals comprising clusters 6, 7, 20, 21, 32, and 44. This mound was scored as present (1) in those six clusters and absent (0) for all the others. These data were then cluster analyzed (CA-C) employing the same technique as above. The results indicated grouping of similar tumuli as derived from the frequency of similar burial attributes.

The final evaluation of data on Individual Bodies involved tests of significance of frequency distributions. This entailed testing for age-related and for sex-related associations among the attributes listed in Table 14. For this analysis, 'ossuary' was separated from 'Body Preparation' and placed in a category of its own. SPSS procedures for contigency table analysis employing the subprogram CROSSTABS was used (Nie and others 1975: Chapter 16). The chi-square statistic tested for significance among the variables. Each attribute was cross-tabulated by age and sex in a contingency table composed of cells characterized by the attributes. Age was divided into subadult (0-15 years) and adult (16-55 years); sex, of course, consisted of individuals, all adults, of known sex. For each division (age and sex) then, five contingency tables were computed.

To summarize, the analysis of Individual Bodies involved (1) cluster analyses of (a) the attributes of all individuals (CA-A), (b) individual attributes excluding age and sex (CA-B), and (c) the results of CA-A to assess like tumuli (CA-C); (2) chi-square tests of the individual attributes by age and sex.

2. Results

As these data were subjected to two types of analyses, cluster and chi-square (X^2), each is alloted separate discussion. The former, it is recalled, was subdivided into Cluster Analysis-A, B, and C (CA-A, CA-B, and CA-C), where all attributes participated, where age and sex were excluded, and where tumuli were clustered from data derived from CA-A, respectively.

Cluster Analyses

The primary goal of the Cluster Analyses A and B was to segregate the interments into groups accorded similar forms of burial. CA-A sought <u>any</u> distinction or pattern among the variables. CA-B allowed burial distinctions to form along the lines of age and/or sex if the pattern existed among the remaining variables. The cophenetic correlation coefficients for the two analyses were .76 and .73, respectively, indicating that a slightly better representation of the data was obtained when considering all attributes including age and sex. The cophenetic correlations, coupled with subjective interpretation of the groupings, demonstrate the failure of the cluster analyses to partition the data into socially distinct groups; random patterns emerged from the data and none of the variables or combinations of variables were distinctive of a particular age and/or sex.

Regardless of the randomness of the variation in the individual burials, a classification of the tumuli based upon Individual Bodies was desired. As the data generated from the classification were not intended to stand alone but be substantiated by comparison with two other sources, the results of CA-A were input for CA-C.

CA-C was interpreted as forming 16 clusters from 48 tumuli (Table 15). Five contained only a single tumulus, with the majority consisting of two to five tumuli. The largest cluster held ten tumuli. The cophenetic correlation coefficient was low (.75) indicating that the dendrogram was not an adequate means of portrayal of the data. As the results of the Cluster Analyses A and B were amorphous, the role these data (CA-C) are capable of assuming in the final assessment of like tumuli is as a weak test of the results of Burial Types and Tumuli Features.

Chi-Square

The results of the cross-tabulation between the sexes and between subadults and adults are given in Appendix VI. The cross-tabulation closely follows the attribute and variable list of Individual Bodies in Table 14.[3]

There were several cells per attribute that could be subsumed under a more general heading, i.e., central vs. non-central. By lumping such cells into more generalized aggregates and comparing their frequencies, general trends are enhanced although subtleties may be lost.

[3] To distinguish the X^2 tabled attributes from the descriptive data of Individual Bodies, they will be underscored.

TABLE 15

Results of the Cluster Analysis of Like Tumuli (CA-C)

Tumuli	Cluster
HI135, SR141, CE104	1
SR138	2
BE118	3
PO305, DA237, PO304, PO165, BE137	4
CE148, DA222, DA246	5
BE117, HI18, HI30, DD201, CE122	6
CE152, CE190, HI30c, CE198, PO301, SR111, DA216, CE154, HE150, BE136	7
BE6/1, BE6/3, BE6/4, HE139, HE147	8
CE123	9
CE150	10
BE135, PO307	11
BE3, BE128	12
DA225, PO306	13
DA226, DA219, BE6/2, PO300	14
HI149	15
DA221, DA250	16

The X^2 results were substantiated in the comparison between the sexes and the ages when the frequencies of non-secondary vs. secondary and central vs. non-central burials were compared. The preponderance of 50/50 splits in the cells of the latter (sexed) is noteworthy (Table 47 in Appendix VI) as it is suggestive of patterned similarity between the sexes. Further, a sex difference was observed in that there were more males buried within a chamber than females, yet more women were interred in pits than men (Table 47 in Appendix VI). Similar subtle differences were noted between the ages: all non-central pit and chamber burials were of adults, and adults predominated the central surface, pit and superimposed burials (Table 52 in Appendix VI).

Within the categories of sex and age, slightly more females (49.1%) were non-secondary interments than males (40.4%); the majority of subadults (74.3%) were secondary as were most of the adults (74.1%). Although it may be an artifact of preservation, the subadults were usually bundles whereas broadcast burials[4] predominantly contained adults (Table 50 in Appendix VI). Generalized provenience revealed a slightly higher percentage of males (72.7%) occupying central positions as opposed to females (69.4%). The lack of distinctive treatment between subadults and adults was maintained regarding provenience: 73.5% of the subadults and 73.6% of the adults were non-central.

Statements pertinent to actual burial practices cannot be formulated from the small samples available, yet some multiple burial combinations deserve mention. The following is a generalized break-down by the number of individuals comprising the multiple interments:

	Double	Triple	Multiple (3+)
Females	13	8	6
Males	9	7	8
Subadults	8	10	15
Adults	23	15	14

The distribution shows few differences and these data acquire meaning with the added knowledge of their constituents. First, it is worth remarking on the occurrence of subadults mainly in a combination of three or more individuals as opposed to the predominant double burial of adults. Considering the constituent of sex, only males occur with a female and children; two females were never buried with more than one child; a single female may be buried with more than one child, but when there were two or more females, there was

[4]Broadcast burials consist of fragmented burned and unburned human bone scattered through the tumuli.

only one child. Basically, there were never females and children buried together unless accompanied by a male. A female may be buried with two males and a child (or children), but only in a single tumulus was a single male buried with more than one female and children (23DA225). Two females occurred together often, but two males were never buried alone together.

Considering the age groups, children occurred only with both sexes, with one exception: 23CE122 contained a multiple burial of a female and two children. Single males and single females had equal probabilities of being accompanied by a subadult. Throughout both categories (sex and age), variability was much in evidence regarding the form a multiple burial assumed. Additional variability derived from single occurrences which were not included in the analysis, of course, and there were many. In general then, it seems that in the midst of tremendous variation the adults were accorded greater autonomy whereas subadults were identified with elders; that heterosexual interments were predominant, although when a unisexual burial did occur, it involved females; and that females, with one exception (23DA225), never out-numbered the males in multiple burials involving subadults.

Significantly more adults were burned than subadults (Table 51 in Appendix VI). This may in part be related to the larger percentage of adult broadcast burials (which may, in turn, reflect inaccurate age assessment) or to preservation. The possibility that burning was a burial treatment primarily for adults cannot be excluded, however.

Burial Types

1. Methods

Table 16 presents the forms of interment found in southwest Missouri burial tumuli. The types listed were observed on more than one occasion. A tumulus-by-tumulus description of burial types is given in Appendix IV. The similarity to Individual Bodies is undoubtedly noted (Table 14). Burial Types, however, was a coarser analysis of the interment process and lacked the fine focus of Individual Bodies. In the present study, all tumuli were included in the analysis except 23HI18. For some unfathomable reason the computer refused to digest the data from this cairn. The sample, then, consisted of 47 tumuli.

A tumulus was ordinally scored as unknown, absent, or present for each variable listed in Table 16. Jaccard's coefficient was used to measure the similarity. The data were analyzed by the technique of multidimensional scaling. A program of non-metric multidimensional scaling, TORSCA-9, was used (Young 1968). The data were row-standardized, i.e., by case, and a symmetric Euclidian distance matrix was

TABLE 16

Elements of Burial Types Used in the Analysis

Extended	
Flexed/Semi-flexed	
Rearticulated:	unburned
	burned
Bundle:	unburned
	burned
Ossuary:	unburned
	burned
Broadcast burial:	unburned
	burned
Concentrated broadcast	
Perimeter burial	
Primary remains:	unburned
	burned
Multiple burial	

formed. The lower left triangle of this mode was interpreted. The initial configuration derived from the data was set by 40 iterations and 80 iterations were allowed maximally for the scaling algorithm. The cases are represented by points in multidimensional space in the configuration. The objective is the "attempt to capture fundamental properties of the objects [variables] under study solely by setting them into correspondence with positions within a spatial continuum" (Shepard 1972: 1). In this way, significant features of the data are revealed in the pattern and structure among the points.

2. Results

The primary purpose of multidimensional scaling is to provide a better understanding of the total pattern of interrelationships in the data. The interrelationships are realized by casting the data into configurations of a designated number of dimensions with a greater degree of stress exhibited by lower dimensional solutions. This stress numerically expresses the goodness of fit between the interpoint distances in the original space and in the reduced space (Kruskal 1964). Stress values range from 0.0 to 1.0, with smaller values indicating better fit. The stress values for Burial Types and Tumuli Features are plotted in Figure 17 in Appendix VIIa. Kruskal (1964: 3) suggests a value of .1 to be a fair measure of fit, and values larger than .2 to be poor. The location of the 'elbow' in the curve of plotted values as well as Kruskal's guidelines should be considered when selecting a dimension suitable for interpretation. The 'elbow' for both Burial Types and Tumuli Features occurs on the 5th Dimensional configuration and the stress values are better than fair (Fig. 17 in Appendix VIIa). Thus, Dimension 5 was chosen and plots of all combinations were generated, i.e., Dimension 1 vs. Dimension 2, Dimension 1 vs. Dimension 3, Dimension 2 vs. Dimension 3, etc.

Included in TORSCA-9 is rotation of the configuration by the Varimax criterion. Such rotation brings the relationship between the variables and axes into better focus and enhances their interpretability. Therefore, the rotated configuration values were interpreted and are given in Appendix VIIb. These values, evaluated in conjunction with the spatial distribution of points at each configuration, segregated the tumuli. The primary variable(s) characterizing each dimension were determined from the traits shared by those tumuli yielding high positive and negative values. The segregating characteristics of each dimension are given in Table 17. This table may impart the impression that the tumuli were split into only two groups, but in five different ways. This is not so. Between the extreme values, the many variables took intermediate values. Several tumuli consistently clustered out together at most of the dimensions.

TABLE 17

Characteristics of the Five Dimensions for Burial Types

Dimension	High Negative	High Positive
1	Broadcast burned burials only.	Singular occurrence of any type other than broadcast and unburned.
2	None are articulated; only unburned bundle burials.	Articulated and burned and unburned bundle burials; majority also have multiple burials.
3	No primary remains or broadcast burials; unburned or burned bundle burial plus one other type.	Either unburned or burned primary remains, broadcast burials or both only.
4	Any combination other than extended, articulated burials.	Extended, articulated burials.
5	Articulated burials; less variable than positive.	No articulated burials, ossuary, primary remains unburned, bundle burials unburned and broadcast burials burned are common to all.

TABLE 18

Groupings of Similar Tumuli Based Upon
Burial Types

Tumuli	Group
PO165, DA216, PO301, SR111	1
BE137, BE6/4, BE6/3	2
DA237, PO305	3
HI30, CE190, HI30c, BE117, DA246, SR141	4
HI135, BE118, HI149, HI18	5
HE139, CE148, CE150, DA225, DA226, PO306, PO307, BE136, SR138	6
DA222, BE6 1, BE135	7
BE6/2, BE3, BE128, CE122, DA219	8
CE104, DA201	9
CE123, PO300, HE147	10
CE152	11
CE154	12
CE198	13
HE150	14
PO304	15
DA250	16
DA221	17

Others, in showing little tendency to couple, indicated a high degree of heterogeneity in the data.

In order to determine a degree of affiliation among the tumuli, the times a tumulus clustered with any other tumulus in each configuration was tallied. The 5th Dimensional solution set the maximum number of co-occurrences at ten (five dimensions plotted two at a time), a score which indicated a clustering together through all dimensional configurations. An evaluation of the tumuli common at eight and at seven co-occurrences showed the latter to form groups that best represented the data. The 48 tumuli separated into 17 groups, seven of which were self-contained or unique (Table 18). 23HI18 was subjectively placed into Group 5 based upon the high concordance with tumuli in that group.

Tumuli Features

1. Methods

The variables which were coded for are given in Table 19. In Appendix V, a tumulus-by-tumulus description is provided. As with Burial Types, the computer disdained the input from some of the tumuli: 23HI135, 23HI30c, 23BE6/4 and 23HE139. Therefore, a total of 44 tumuli contributed to the analysis.

The same coding and multivariate technique utilized in the analysis of Burial Types was used: ordinally scored data and TORSCA-9 multidimensional scaling procedures, respectively.

2. Results

The dimension chosen for interpretation (the 5th) and the reasoning behind the selection were discussed above. Again, the rotated values, which are listed in Appendix VIII, were interpreted.

As above, the characteristics of each dimension were determined from the variables common to tumuli aggregating at the polar values (Table 20). As observed in Table 20, mounds and cairns (Dimension 2) were differentiated. The dichotomy was given special attention for two basic reasons: (1) the construction of a mound as opposed to a cairn or the status of the structure upon discovery might be explicable environmentally rather than behaviorally; (2) not all cairns were simple just as not all mounds were complex, and the intergrading between the extremes, especially the areas of overlap, required a closer inspection. Dimension 2 was, therefore, interpreted with and without regard to the mound/cairn dichotomy. The scrutiny revealed several tumuli which differed only on that variable. Hence, in the tumuli that

TABLE 19

Variables of Tumuli Features Used in the Analysis

Mound or cairn

Tumulus alteration

Masonry chamber

Within masonry chamber

- Individual burial
  - Unburned
  - Burned
- Broadcast burial
  - Unburned
  - Burned
- Pit burial
  - Unburned
  - Burned

Individual burial pit(s)

Within a pit

- Individual burial
  - Unburned
  - Burned
- Creamation

Feature[+]

Burned artifacts

Burned rock

- In the fill
- On the tumulus base

Superimposed burial(s)

[+]Includes non-interment alterations of the tumuli such as rock-filled pits.

TABLE 20

Characteristics of the Five Dimensions
For Tumuli Features

Dimension	High Negative	High Positive
1	Tumuli without alteration.	Tumuli with alteration.
2	Cairns lacking variability.	Mounds with much variability.
3	Mounds with little variability and no burned artifacts.	Mounds with burned artifacts.
4	No burial superimposition or burned rock fill.	Burial superimposition and burned rock fill.
5	No masonry chamber or burial pit.	Masonry chamber and burial pit outside the chamber.

TABLE 21

Groupings of Similar Tumuli
Based Upon Tumuli Features

Tumuli	Group
HI18, HE150, PO304, HE147, PO165, HI135, HI30c, BE6/4, HE139	1
PO305, HI149, DA221, DA237	2
CE152, BE6/1, BE6/2, DA246, DA222, BE128, SR138, PO301, DA226, BE118, SR111, SR141, CE123, DO201	3
CE154, PO306, BE117, DA219, CE190	4
DA225, CE148	5
BE6/3, DA216	6
CE150, BE135, PO300	7
CE122, DA250, CE198, BE3, HI30	8
BE136, PO307, CE104, BE137	9

were nearly indistinguishable except for the mound/cairn differentiation, the dichotomy was ignored. The groupings that result (Table 21), then, contain both mounds and cairns when the lumping was warranted. Similar to Burial Types, the clusters were formed from seven co-occurrences, with the four tumuli not included in the computer manipulation fitted subjectively. Although seven co-occurrences were considered satisfactory, the majority shared ten, indicating a close affinity within the groups. Some tumuli, which would otherwise have been self-contained, were included on the basis of six co-occurrences. This was permissible only when the seventh was denied by a difference in 'burned rock.' The flexibility was felt justified as this variable was susceptible to vagaries of excavation technique, the ability to recognize evidence of firing, and the presence of a great quantity of small rocks within the tumuli, not all of which could realistically be inspected during excavation. Also, as meaningful similarities were sought among all the tumuli, the self-contained tumuli, unless genuinely distinctive, are not meaningful in a comparative study. Thus, nine groups were formed from the 48 tumuli, none of which were self-contained and one of which was composed of cairns only (Group 6).

Tumuli Co-Occurrence

1. Methods

A comparison among the tumuli based exclusively on the results from Individual Bodies (CA-C), Burial Types, and Tumuli Features was undertaken. A similarity matrix tallying the instances each tumulus occurred with every other tumulus in the three multivariate analyses described above was compiled by hand. The maximum number of possible co-occurrences was three. Tumuli that grouped together in all three analyses may be interpreted as having a great deal of similarity in common. The minimum number of co-occurrences was 0, indicating a degree of contrast between the tumuli. As there was minimal regularity to the distribution in the number of co-occurrences among some of the tumuli, subjective appraisal was necessary. In allowing subjectivity to contribute to the results, theoretical issues involving the relative cultural, behavioral and biological significance of the three analyses had to be considered. A thorough knowledge and familiarity with the material was invaluable, yet it did little to alleviate bias in the results. The relative weight merited by each analysis was felt to be that Burial Types and Individual Bodies were more critical as indicators of behavior than Tumuli Features. The greatest weight would ideally be attached to Individual Bodies but as we shall see this was not possible. A further digression into the subjective processes that were applied in the final grouping of tumuli is not warranted or even possible.

Suffice it to be noted that the results of Tumuli Co-Occurrence did involve subjectivity; yet only a few tumuli needed such appraisal. In this way, the tumuli were arranged into groups based upon similarities expressed in human content and manipulation and by the structural features of the cemetery.

2. Results

Not to be confused with the method of grouping the Burial Types and Tumuli Features, the following considered the data from those analyses and from Individual Bodies in order to formulate aggregates of tumuli that most closely resemble one another. Nine groups, designated A-I inclusive, were formed, while three tumuli remained self-contained and three were indeterminate. The groups are presented in tabular form (Table 22) and their spatial distribution within the study area is depicted in Figure 12. Subjective appraisal was required in placing 23DA201, CE150, CE152, and DA216 into their respective groups and in the formulation of Groups H and I. Thus, the majority of tumuli groups were confidently and strongly bonded on the basis of distinctive similarities.

Discussion and Conclusions

The format followed in the previous sections is abandoned here in favor of a unifying presentation of the data. A brief critique of cluster analysis technique is followed by a commentary regarding social organization.

A brief statement regarding the use of cluster analysis as a technique in evaluating mortuary data, without becoming embroiled in nuances of multivariate statistics, seems warranted. Much of the following paraphrases J. Tainter (1975; 1978) who is a critic of numerical classificatory procedures involving mortuary data.

The result of Tainter's research seems to indicate that cluster analysis techniques are inappropriate for mortuary data. The negativity arises primarily because the clusters generated through these procedures do not reflect social distinctions (for an opposing view see Rothschild 1979). As an alternative, Tainter proposes monothetic-divisive procedures as a way of subdividing a population into maximally homogeneous subgroups. He especially advocates the information statistic as capable of providing superior results (see Tainter 1975: 11 for details). However, the monothetic-divisive procedure is not a multivariate technique. It is, rather, a repetitive bivariate technique of formal analysis. That is, only two variables are contrasted simultaneously; the statistic is incapable of viewing a variable in relation to all other variables. Presently then, regardless of the dissatisfaction in the results which may reflect the data

TABLE 22

Final Grouping of Tumuli as Determined From Tumuli Co-occurrence

Tumuli	Group
BE6/2, BE3, BE128, BE117, HE150, SR138, HI30, HI30c, CE122, CE154, CE190, DA219, DA201, DA226	A
PO306, CE148, CE150, DA225	B
BE6/1, SR141, DA222, DA246	C
BE136, PO307	D
BE6/3, BE6/4, HE139, HE147	E
PO305, DA237	F
SR111, PO301, CE152, DA216	G
BE118, HI18, HI135, HI149, CE104	H
BE137, PO165, PO304	I
DA221	self-contained
CE198	self-contained
DA250	self-contained
PO300	indeterminate
CE123	indeterminate
BE135	indeterminate

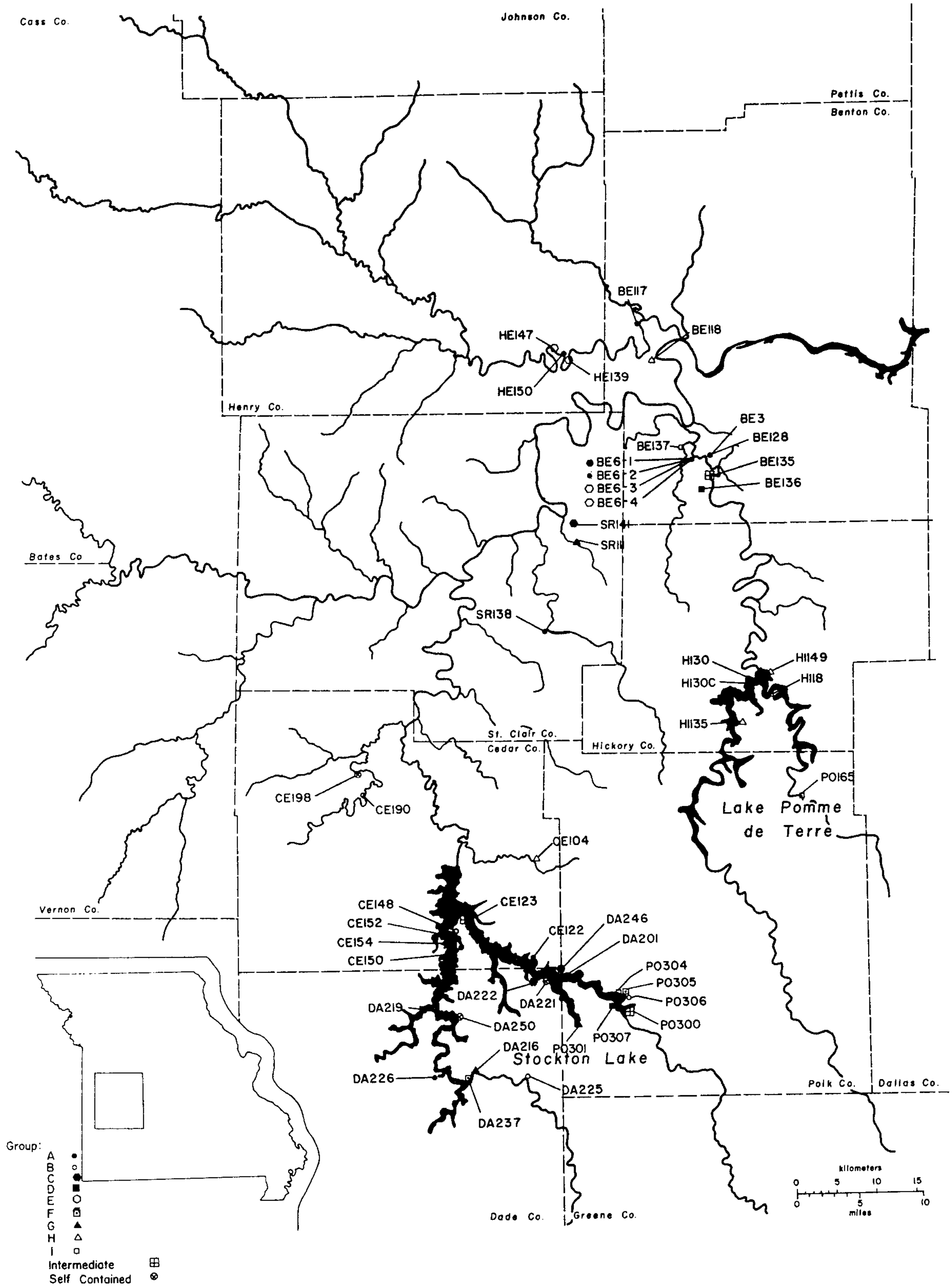

Figure 12. Spatial distribution of groups of similar tumuli.

set instead of the statistic, cluster analysis is the most favorable multivariate technique of segregating a complex and large body of data into aggregates with common characteristics.

In determining the interaction of the variables between the sexes and between subadults and adults, chi-square analysis proved superior to cluster analysis. The contingency table analysis succinctly revealed the randomness of the data by displaying the variability. This variability must be understood in terms of the organizational properties of the cultural system. Yet, statements concerning social organization from the interment data were initially quite problematical because the variability was underlain by regional isomorphism.

At this point it is advantageous to step back from the mortuary data and look at the settlement-subsistence system postulated for the Osage River Basin region of southwest Missouri (see Roper, ed. 1980 for full details). It has been argued (Roper 1978; Roper, ed. 1980) that the Osage River Basin, although containing a wide variety of exploitable resources, was incapable of providing sufficient quantities of major resources to support a large, aggregate population. Analyses of site location, site-size, projectile point and tool types from the numerous sites suggest a utilization of the region and a distribution across the landscape of peoples practicing primarily a hunting and gathering economy. The data further indicate that this way of life, established at least following the close of the Hypsithermal, persisted probably up to Euro-American contact. Thus, cultural continuity in the Ozarks is perceived to span the periods referred to as the Late Archaic, Early, Middle, and Late Woodland, and Mississippian.

It follows that for successful occupation of the region, the population would consist of small, highly mobile groups analogous to the "foragers" of Binford (1980). The groups were probably kinship units likened to the band compositions of segmental societies (Service 1975). As such, interrelationships were probably egalitarian and organizational structure ephermeral, being limited to an 'at the moment' sort of leadership assumed by anyone capable of satisfying the immediate need. Contact with other groups within the area probably occurred often enough to result in cultural and biological uniformity within the regions through time. There is artifactual evidence of contact with populations outside the area (i.e., Hopewell and Mississippian). It is certain that the southwestern Missouri population was aware of major cultural changes occurring in surrounding areas. However, environmental limitations and the nature of their adaptation both environmentally and socially precluded active participation by the southwest Missourians.

Resuming the discussion of burial practices, ismorphism was seen to exist throughout the area in:

1. bluff-top cemeteries,
2. tumuli as a disposal facility,
3. constancy in the amount of variation in burial types, and
4. equal treatment of individuals regardless of age and/or sex.

The variation observed was primarily within each tumulus and involved:

1. internal alteration of the tumulus to accommodate the interments,
2. burial types,
3. age and sex affiliation with the burial types, and
4. artifactual content.

Direct demonstration of the isomorphism and variability was provided through the cluster analysis. The former was revealed in the lack of spatial and temporal patterning in the clusters, and the inability to form groupings of distinct individuals reflected the variability. These isomorphic and variable tendencies were also seen in the X^2 tests.

The manifestation of mortuary behavior may be interpreted in conjunction with the settlement-subsistence system postulated above. It is generally agreed that in an egalitarian society the sociocultural system as reflected in burial treatment is closely tied to age, sex, and personal achievement (Saxe 1970; Fried 1967). As shown, social or status distinctions were not well-defined in southwestern Missouri. Adults were recognized as being accorded central place burial and burning with greater frequency than subadults. A division on the basis of age may be tenuously advanced. Considering the cultural and biological evidence then, the following is postulated to be characteristic of the prehistoric inhabitants of southwestern Missouri, with special regard to mortuary practices: small, mobile groups of foraging people were following a regionally recognized way of life and personalized or tailored a particular behavior (mortuary) to suit their group needs.

CHAPTER IV

DENTAL ANALYSIS

Introduction

Chapter Orientation

The purpose of this chapter is to discuss rate of tooth wear, incidence of oral pathology, and interrelationships among specific dentofacial measurements. These data are also analyzed for sex-related differences and are used in determining whether corn was accessible to a particular segment of the population. Additionally, these analyses substantiate the results obtained in the previous chapters. Chapter II, DEMOGRAPHY, demonstrated a lack of skeletal evidence for differential access to corn; and Chapter III, BURIAL DYNAMICS, disclosed the egalitarian treatment accorded all individuals regardless of age or sex. Should sex-related or subsistence-related differences be observed in the dental analyses, a reassessment of all findings will be necessary.

Dental Anthropology and Subsistence

Numerous studies have shown that the kind and degree of tooth wear are related to the culture of a population (Scott 1974; Walker 1978; Molnar 1971a, 1971b, 1972; Smith 1972; Leigh 1925; Moorress 1957; Stewart and others n.d.; Brace 1962; Brothwell 1963). The relationship between dentition and culturally mediated food procurement and processing activities will be studied on three levels: dental attrition, dental and oral pathology, and dentofacial metrics (Scott 1974: 10). A review of the relevant literature and an introduction to the attributes significant to the analysis of each of these three parameters follows.

Attrition

The term attrition, defined by Moorress (1957: 129), as the frictional wear of teeth, is descriptive of all forms of enamel and dentine reduction. Other variables such as abrasion (via food material), cultural practices (i.e., using the teeth as tool supplements), and individual idiosyncratic behaviors (i.e., bruxism) contribute to the over-all degree of dental attrition. Examination of the dentition in general and of attrition specifically can potentially yield data pertinent to the culture of a population and to some of the behaviors of the individual.

The value of many dental anthropology studies to archeology is limited because they are not comparable. The focus of the studies such as those by Davies (1963), Smith (1972), Molnar (1971a, 1971b), and Leigh (1925) is on dental attrition as measured by the degree of wear. Teeth are subjectively evaluated, then ranked on an ordinal scale with a lower number corresponding to less wear. The difficulty in comparability of the data generated by these methods arises from the determination of dental attrition of each population without regard to the age profile. The data are usually expressed in central tendency statistics, and such values, lacking correction for age, are misleading and prone to gross interpretational error.

A method, first advanced by Smith (1972) and subsequently modified by Robert A. Benfer (see Scott 1974), compares the wear between adjacent teeth. The method quantifies the amount or rate of attrition during a fairly constant time interval and is independent of age. For example, the difference in the degree of attrition of the first molar (M1) and the second molar (M2) is an index of the wear rate for the six year interval between eruption of the M1 and M2. Other techniques of assessing the rate of attrition require immature dentition or sophisticated equipment not readily available to most researchers (Miles 1963; Walker 1978). The methodology devised by Benfer and applied by Scott (1974) is followed in this study.

Dental and Oral Pathology

Oral health is strongly influenced by diet, as well as heredity. The incidence of caries, abscessing and periodontal disease are not only related to the nature of the food consumed but also to how it is prepared and ingested, as well as the individual's susceptibility to enamel decay (Moorress 1957; Brothwell 1963; Molnar 1971a, 1972; Scott 1974; Leigh 1937; Dewey 1972). Discussion of dental pathology in this study is limited to antemortem loss, abscessing, caries and periodontal disease as these are influenced by subsistence differences, and are measurable in a skeletal series.

It does not always follow that the loss of a tooth resulted from a pathological condition. The face is a noticeable area of bodily adornment and it is not unusual for the teeth to be involved in cosmetic changes. This may entail mutilation-modification procedures or ritual ablation. Such practices may be recognized if there is patterning to the ablation. Accidental trauma is another reason for tooth loss. This may be detected by the absence of infection in the supporting structures, or merely a localized response without involvement of surrounding tissue. Pathological edentulation can be attributed to various agents. Tooth decay and

alveolar inflammation leading to deterioration of the alveolus are two of the more common. The detection of loss can be complicated by healing and concomitant alveolar resorption, and by congenital absence or non-eruption of a tooth. In this study, those few individuals displaying tooth loss were in such poor oral health that the diagnosis was fairly straight-forward.

An important result of antemortem loss not often considered is the increased stress it places on the remaining teeth (Dewey 1972; Poirier 1972). The stress is reflected in the greater attrition on such teeth.

An abscess occurs as the result of an infection leading to the destruction of bone surrounding a tooth, commonly at the apex of the root. The circular pit created is generally easy to recognize. The nature of the bone destruction is readily discernible from post-mortem damage by the location, regularity and symmetry of the depression and in the smoothness of the margins. Some abscesses do heal, through bone remodeling, and not all result in the loss of the affected tooth.

Caries are assessed by the extent of the damage rather than simple presence/absence. Differential susceptibility to caries is a possibility but the data are still insufficient (Fulton et al. 1965; Scopp 1973; Spouge 1973). Enamel caries are caused by the corrosive activity of acids that are produced by bacteria (Spouge 1973; Scopp 1973). Diet and nutrition can directly influence caries formation as a primary source of decay-causing agents and through their involvement in providing the building-blocks for tooth enamel (Rose and Boyd 1978; Molnar and Ward 1972). Significant factors in dental decay are the amount of carbohydrates in the diet, the consistency of foods ingested, and the inherited variation in enamel hardness (Molnar 1972; Turner 1979; Cook and Buikstra 1979). Basically, a high proportion of carbohydrates is positively correlated with caries, and stickier foods are retained in the intersticies of the teeth, thus propagating bacterial growth.

Periodontal disease is primarily a disease of the surrounding soft, membraneous tissue and only affects the bony structure in severe cases. It is, therefore, difficult to assess in a skeletal series, and detection of afflicted persons will include only chronic cases affecting the alveolar bone. Scopp states (1973: 59), "There is no disease in adults that has a greater incidence than periodontal disease. It is the most frequent cause of suffering and inconvenience in man, . . ." Of course, he was referring to modern populations with great reliance upon refined flours and sugars. Thus an estimate of an archeological population lacking the processed carbohydrates may not be grossly distorted if approached cautiously and based on several indicators.

TABLE 23

Sample Used in Dental Analyses

Burial	Age	Sex	Rate of Wear	Caries, Abscess Periodonal Disease	Mandible	Maxilla	Orofacial
PO 300 2*	46+ yr.	M	+	+	+	+	+
HE 147 1	30-40 yr.	F	+	+	+	-	-
HE 147 2	20-25 yr.	F	+	+	+	+	+
BE 137 1	35-40 yr.	F	+	+	+	-	+
PO 307 2*	35-40 yr.	M	+	+	+	+	-
PO 307 4a	45+ yr.	F	+	+	+	+	+
PO 307 6	20-25 yr.	F	+	+	+	-	-
CE 150 1a*	20-25 yr.	F	+	+	+	+	+
CE 150 3	20-25 yr.	M	+	+	+	+	+
CE 150 6	25-35 yr.	M	+	+	+	+	+
CE 150 7	35-45 yr.	M	+	+	+	+	+
DA 225 1*	20-25 yr.	F	+	+	+	+	+
DA 226 1*	40-45 yr.	M	+	+	+	-	-
DA 226 4a	35-40 yr.	M	+	+	-	-	-
DA 226 4c	45+ yr.	F	-	+	-	-	-
DA 246 3*	30-35 yr.	F	+	+	+	-	-
DA 246 4	40-45 yr.	F	+	+	+	-	+
HE 150 1	22-28 yr.	F	+	+	-	+	-
HE 150 2	18-19 yr.	M	+	+	+	-	+
DA 201 1	40+ yr.	F	+	+	+	-	-
HE 139 2	18-20 yr.	F	+	+	+	-	-
CE 122 2b	25-35 yr.	F	+	+	+	-	-
BE 128 2	23-28 yr.	F	+	+	+	-	+
BEG/1 2a	40+ yr.	M	+	+	+	-	-
BEG/2 1a	22-27 yr.	M	+	+	-	+	-
BEG/2 1b	45+ yr.	M	-	+	-	-	-
BEG/2 3	20-30 yr.	M	+	+	+	+	-
BEG/2 4	25-35 yr.	M	+	+	-	+	-
PO 306 4*	45+ yr.	M	+	+	+	-	+
PO 306 5a	20-25 yr.	F	+	+	+	+	+
PO 306 5b	18-20 yr.	F	+	+	-	+	-
PO 306 6a	20-21 yr.	F	+	+	+	+	+
TOTAL 32 ind.		F = 18 M = 14	30	32	25	16	15

*Tumuli with corn

Dentofacial Metrics

Orofacial and dental metrics were taken to quantify degree of fluctuating asymmetry and to measure any association between subsistence pattern and orofacial architecture. Fluctuating dental asymmetry (asymmetry favoring neither side) has been shown to be related to differences in diet and health (Perzigian 1977a, 1977b; Bailit and others 1970; DiBennardio and Bailit 1978). Inbreeding may also increase asymmetry (Suarez 1974) although the evidence is inconclusive. As differential access to a resource (corn) is being tested, and as southwest Missouri is argued as maintaining a stable, fairly isolated population (Goldberg 1980; Roper 1978), asymmetry should be studied.

Methods

This section describes the sample, the methods of data collection, and the methods of analysis. The techniques of data collection and analysis are presented separately to promote clarity as three investigative procedures are involved: Attrition, Dental and Oral Pathology, and Dentofacial Metrics.

The Sample

The sample consisted of those adults (18+ years) with fairly intact orofacial apparatus plus associated teeth. If differential preservation and method of burial processing are unbiased events, then the sample was randomly selected from the recovered skeletal series. The major bias inherent in the data would be the dearth of broadcast individuals. Remains representative of such interments were invariably too fragmentary and incomplete for adequate observation. Table 23 shows the break-down of the sample for separate analyses. As indicated, not all 32 individuals participated in every analysis. A total of 16 tumuli contributed to the sample, allowing the series to be further divided into seven tumuli containing corn (18 individuals) and nine tumuli lacking corn (14 individuals).

Methods of Data Collection

Attrition

Initially, the degree of dental attrition was determined for each molar tooth using the eight point ordinal scale developed by Molnar (1971a).[5] The form the data assumed allowed the assessment of a measure of attrition independent of age (see Scott 1974: 75ff for a full discussion). The

[5]See Appendix IXa.

measure is of the wear difference between adjacent molar teeth which erupt almost invariably at six year intervals (Fanning and Moorress 1969). Teeth worn to root level (7 or more on Molnar's scale) were omitted from rate analysis as they failed to maintain the original wear differential with the adjacent molar. An approximation of the rate of wear of the population was thus obtained, the techniques of which will be discussed in the Analysis section.

Dental and Oral Pathology

Some observations of the dentition and alveolar margins, although not pathologies per se, were necessary for an evaluation of oral health, especially periodontal disease. Interstitial wear, calculus formation, porosity of the alveolar border, and abscess severity were recorded on an ordinal scale of none (1), slight (2), moderate (3), and extensive (4). Presence/absence data only were obtained for antemortem loss and enamel hypoplasia. The location (occlusal, interstitial, root or smooth surface) plus the degree of severity (1-4) were recorded for carious lesions. The recession of the alveolar bone from the teeth was measured using a short, narrow, plastic ruler. One end of the rule was placed upon the alveolar border, the level at the cervico-enamel junction was then read and the data recorded in millimeters. As discussed by Scott (1974: 61-62), some error is involved in the implementation of such a crude device. However, as measurements over 2.5 mm were of primary interest, small errors were of less consequence.

The assessment of over-all periodontal disease was not a singular observation as above. This particular evaluation indicates the multicausality of and tendency for oral pathologies to occur in complexes of interrelating events (Scott 1974: 96-103). By excluding severely worn teeth from the analysis and by using the following features as indicators, it should be possible to ascertain a degree of periodontal disease: calcular deposits; alveolar porosity; degree of wear; and recession of the alveolar bone (2.5 mm is considered pathological according to Alexandersen 1967). A tooth which showed calculus, porosity, and recession was considered likely to belong to a person suffering from periodontal disease. Those individuals with recession and porosity but no apparent calculus were also likely candidates because calcular deposits are easily erased by post-mortem events. If the wear on such specimens was moderate or less (1-4 on Molnar's scale), the individual was judged to have experienced periodontal disease.

Dentofacial Metrics

The cranial skeleton was usually fragmentary and reconstruction was necessary in all cases. Fragmentation was also responsible for the inability to combine the mandibular,

maxillary, and orofacial data into a single analysis. As shown in Table 23, the sample for such a joint analysis would be quite small. Therefore, the structures were considered separately and the sexes were combined.

The maxillary data required relatively more reconstruction, for the thin osseous structure is more susceptible to post-mortem and depositional damage than is the dense bone of the mandible. A list of the metrics used and their definitions are presented in Appendix IXb.

Methods of Analysis

Attritional Rate

The computation of the first principal axis, which is the major axis of the elipsoid of X and Y, provides a measure of the trend or relationship between the variables X and Y (Sokal and Rohlf 1969). Scott (1974, 1979), applying this method to Peruvian populations, reports that this procedure reliably assessed the dental attrition rate of those populations.

The wear scores derived from Molnar's ordinally scaled system of degree of wear were treated as if intervally scaled and plotted with the molar first to erupt on the X-axis and the molar to erupt second on the Y-axis. A principal axis was then fitted to the scattergram of the bivariate distribution and the angle the principal axis made with the Y-intercept became the comparative statistic. The calculation of the Y-intercept and slope of the major axis were computed by hand (Texas Instrument Sr-51-II) from the equations in Sokal and Rohlf (1969: 526-532). Confidence limits were calculated for the slopes. The method of principal axis analysis does not assume a causal relationship between M1 or M2, nor does it assume the X-axis variable to be measured error-free.

Interpretation of the results describe a low intercept, high slope and less acute angle at the Y-intercept as indicative of a rapid rate of wear and, conversely, a slower rate of wear results in a higher intercept, lower slope and more acute angle.

Pathology

In the analysis of pathological data, the variables were perceived as combinations of interrelating traits. As discussed previously, several indicators occurring simultaneously are needed in adequately evaluating periodontal disease.

The analytic techniques used on the pathological data included bivariate correlation and chi-square (X^2) tests of

significance. Correlation is a measure of how closely two variables are varying. The correlation coefficient (Pearson's Product-Moment 'r'), with a range from -1.0 to +1.0, reflects the degree of interdependence or covariation between pairs of variables in a sample (Sokal and Rohlf 1969: 498-508). A correlation of 0.0 signifies no linear relation between the variables, and extreme values indicate a close relationship.

Dentofacial Metrics

Poor preservation and subsequent fragmentation left gaps in the data. Values for missing data were obtained from the mean of summed values for that particular variable. Considering orofacial metrics, if at least five of the nine measurements could not be taken, the specimen was omitted from the analysis. Only original values were used in assessing asymmetry. The percentage of missing data for each analysis is presented below:

Analysis	% Missing
Mandible buccal-lingual diameter	15.6
Maxilla buccal-lingual diameter	10.6
Orofacial metrics[6]	14.1
TOTAL	13.8

R-mode principal components analysis was selected as an analytic technique appropriate for each data set. The aim of this technique is to reduce the data to a few components which account for much of the covariation in dental and orofacial measurements. Program FACTOR (Veldman 1967) was used in the principal components analysis. One purpose of a factor analysis is to attempt to identify "causal" factors behind correlations in the data (Benfer 1972).

For each data set three principal components with eigenvalues greater than 1.0 were extracted and rotated by the Varimax criterion. The first unrotated principal component is almost always size (Kowalski 1972). Both the unrotated and rotated loadings were interpreted and plotted by group (with corn vs. without corn) for visual comparison.

Discriminant function analysis deals with the problem of ascertaining the variables which best differentiate between previously defined groups. The original data from each set were split into those from tumuli containing corn and those from tumuli without corn. The sample breakdown respective of dentofacial structure and corn is as follows:

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[6] Maxillary breadth accounted for the majority of the missing data.

	Mandible	Maxilla	Orofacial
Tumuli containing corn	15	11	11
Tumuli without corn	10	5	4

The procedure followed in the discriminant function analysis was Program DSCRIM (Veldman 1967). The results were interpreted and plotted. Although the chi-square values were not significant ($p>.10$) for all three analyses, the trends were informative and warrant discussion in the next section.

In assessing fluctuating dental asymmetry, only teeth quantified by original values were used. The sample consisted of those individuals with associated posterior dentition (see Table 23). If maxillary and mandibular teeth were intact, the mandible was used as this structure was by far the more frequent jaw bone available. The following presents the sample size per tooth and jaw used in this study:

	M3	M2	M1	PM2	PM1
Mandible	17	20	22	18	16
Maxilla	4	5	5	5	4
TOTAL	21	25	27	23	20

Degree of asymmetry was determined by intercorrelating the buccal-lingual diameter of a left-side tooth with the same tooth on the right side, e.g., LM1 - RM1. The Pearson's product-moment correlation (r) statistic was used. Correlation, as discussed earlier, is a measure of association between two or more variables. Low correlation coefficients indicate that the variables (e.g., LM1 - RM1) are not covarying closely. In the case of asymmetry, low correlations, as opposed to the usual high values, are meaningful as indicators of stress. Thus, statistically significant values for r were interpreted as 'low asymmetry,' i.e., the antimeres were relatively symmetrical.

Initially, the linear correlations among the teeth were computed. Next, the sample was divided into those individuals from tumuli with corn and those without corn. The relationship between age at death and asymmetry was then quantified for the entire sample; average molar asymmetry was also computed in an effort to assess general health per age group. The age group sample breakdown and the results of the study of dental asymmetry for southwest Missouri are discussed in the following section.

Results

The results of the analyses of Attritional Rate, of Dental and Oral Pathology, and of Dentofacial Metrics follow in respective order. As the analysis of Dentofacial Metrics

involved three techniques, that section is further divided into: Principal Components Analysis, Discriminant Function Analysis, and Fluctuating Dental Asymmetry.

Attritional Rate

As explained in an earlier section, the rate of wear is determined by the angle formed by the principal axis at the Y-intercept and the slope of the major axis. More abtuse angles corresponding to higher slopes suggest a rapid rate of wear, while an acute angle occuring with a low slope denotes a slower rate of wear. Tables 24 through 26 present the results of the analysis for the entire sample, the sample divided on the basis of corn, and the entire sample separated into mandibular and maxillary components, respectively.

The females as a whole experienced a much slower rate of wear than the males (Table 24 and Figure 13). Figure 14 graphically shows that this is especially evident for the females from tumuli containing corn who expressed the slowest rate of wear. Also, a significant difference was found between the two slopes for females with corn and females without corn (F-ratio=8.67, df=34, $p<.05$). The F-ratio suggests that if both samples were in fact randomly drawn from the same population, then the likelihood of observing slopes which differ this much or more by chance is less than 5 in 100.

Referring again to Figure 14, the opposite situation is revealed in tumuli lacking corn, as the males evinced a much slower rate of wear than the females. Further, a strikingly similar rapid rate of wear is depicted between females without corn and males with corn.

Individuals from tumuli containing corn showed an overall slower rate of wear than those from tumuli lacking corn (Figure 15). Individuals from tumuli lacking corn experienced a diet with an abrasive content greater than that for individuals presumably supplementing their diet with corn. However, the difference between the slopes could have been obtained by chance ($p>.05$). Several sources influential in the amount of abrasive material introduced into the mouth other than corn include the consumption of meat without removal of the bones; eating dried fish and tough, fibrous plant foods; reliance upon nuts as a dietary staple; and methods of food preparation (see Molnar 1972). Also, the absence of corn within the cemetery area does not indicate an unawareness or lack of its utilization. The season of burial may predicate the inclusion of a valuable staple in the mortuary ritual. A people may choose to be conservative with their finite amount of stored grain, especially if the harvest is not typically abundant. Implications similar to

TABLE 24

Results of the Principal Axis Analysis of Adjacent Molar Attrition Scores (M1 M2)

	Females N = 40 pairs		Males N = 31 pairs		Combined N = 71 pairs	
	M1	M2	M1	M2	M1	M2
Mean	4.37	3.30	5.09	4.09	4.69	3.64
Variance	1.134	.910	.926	.991	1.171	1.101
Standard deviation	1.078	.966	.978	1.011	1.090	1.057
r	.75		.83		.81	
Equation of principal axis	$y = .359 + .672x$		$y = -.290 + .861x$		$Y = -.031 + .784x$	
95% confidence region	$.617 < b < .729$		$.820 < b < .904$		$.755 < b < .813$	
Slope (b)	.672		.861		.784	
Angle of principal axis with y axis at y intercept	56°		49°		52°	

TABLE 25

Results of the Principal Axis Analysis of Adjacent Molar Attrition Scores (M1 M2)

	Tumuli with Corn						Tumuli Without Corn					
	Females N=20 pairs		Males N=22 pairs		Combined N=42 pairs		Females N=18 pairs		Males N=9 pairs		Combined N-27 pairs	
	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2
Mean	4.25	3.15	5.55	4.45	4.95	3.83	4.66	3.61	4.00	3.22	4.44	3.48
Variance	1.010	.228	.429	.884	1.093	.996	.888	1.459	.444	.173	.840	1.064
Standard deviation	1.031	.489	.671	.963	1.058	1.010	.970	1.243	.707	.441	.934	1.051
r	.64		.78		.77		.86		.80		.83	
Equation of principal axis	y=1.850+.302x		y=-1.731+1.115x		y=.201+.733a		y=-1.542+1.104x		y=1.222+.500x		y=-.680+.936x	
95% confidence region	.258<b<.347		1.054<b<1.180		.622<b<.813		1.000 <b <1.214		.468<b<.626		.932<b<.996	
Slope	.302		.115		.733		1.104		.500		.936	
Angle of principal axis with y axis at y intercept	73°		41.5°		53.5°		42°		63.5°		47°	

TABLE 26

Results of the Principal Axis Analysis of Adjacent Molar Attrition Scores (M_1M_2, M^1M^2) - Sexes Combined

	$\overline{X}$M1 (s.d. M1)	$\overline{X}$M2 (s.d. M2)	N	r	Equation of Principal Axis	95% Confidence Region
			Tumuli With Corn			
Mandibles	4.96 (1.04)	3.85 (1.08)	26	.74	.010 + .773x	.725 < b < .824
Maxillae	4.94 (1.12)	3.81 (.911)	16	.83	.472 + .676x	.637 < b < .716
			Tumuli Without Corn			
Mandibles	4.44 (1.09)	3.61 (1.24)	18	.87	-.761 + .984x	.914 < b < 1.060
Maxillae	4.44 (.527)	3.22 (.441)	9	.60	.999 + .500x	.459 < b < .542
			Combined Tumuli			
Mandibles	4.75 (1.08)	3.75 (1.14)	44	.80	-.244 + .841x	.798 < b < 1.048
Maxillae	4.60 (1.12)	3.50 (.893)	27	.86	.333 + .685x	.650 < b < .721

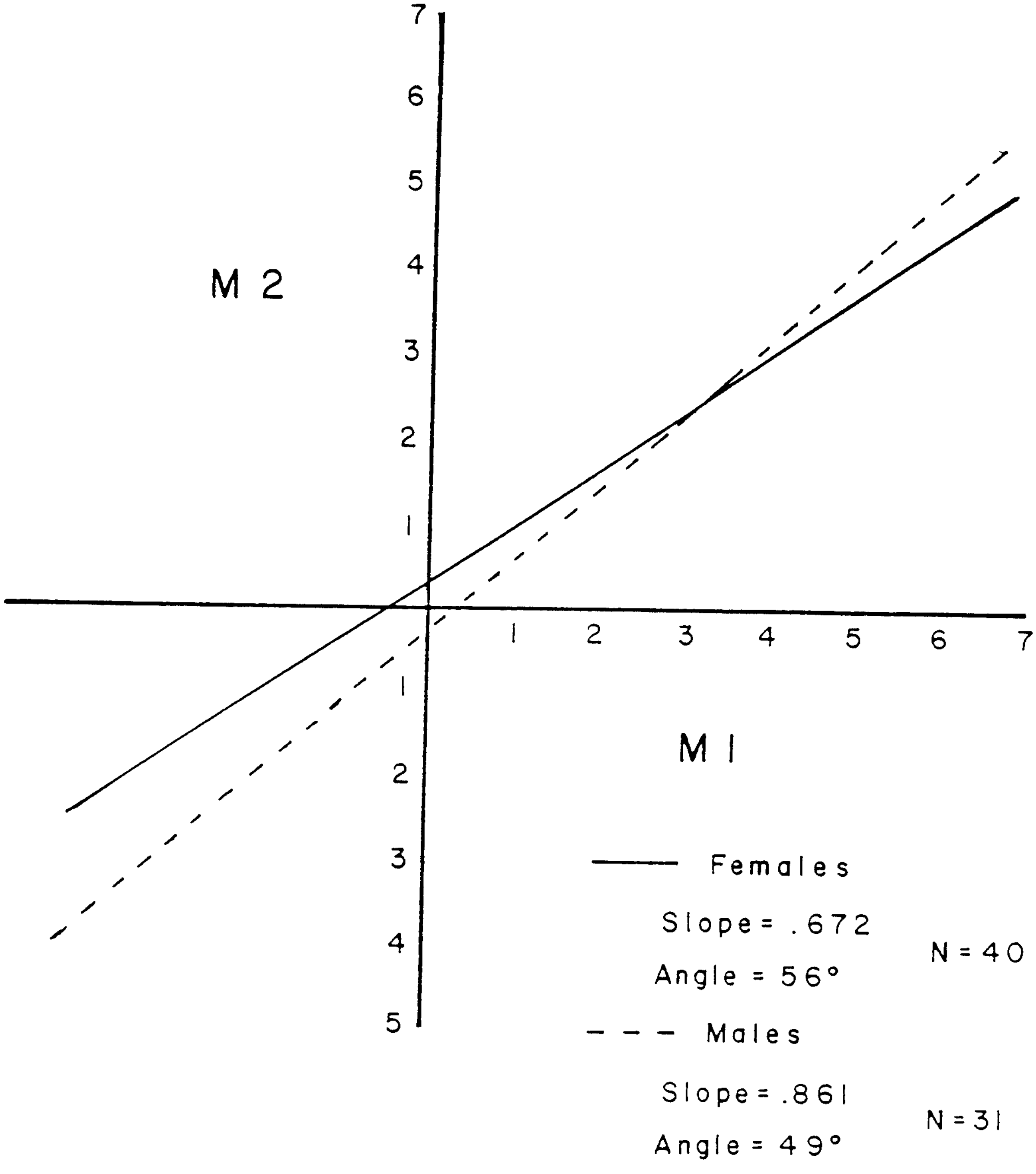

Figure 13. Plot of principal axis for females and males.

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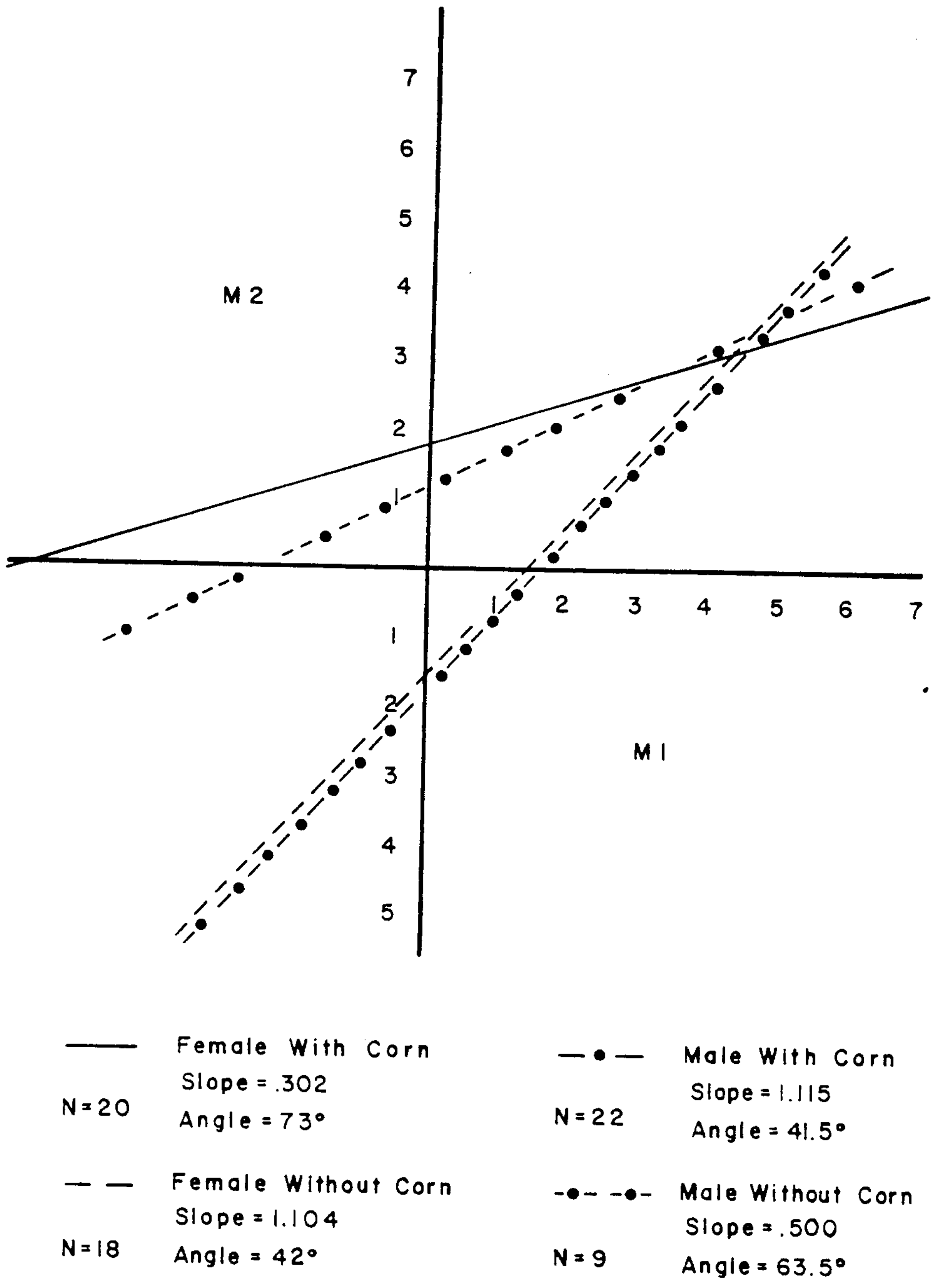

Figure 14. Plot of principal axis for tumuli with corn and tumuli without corn - sexes separate.

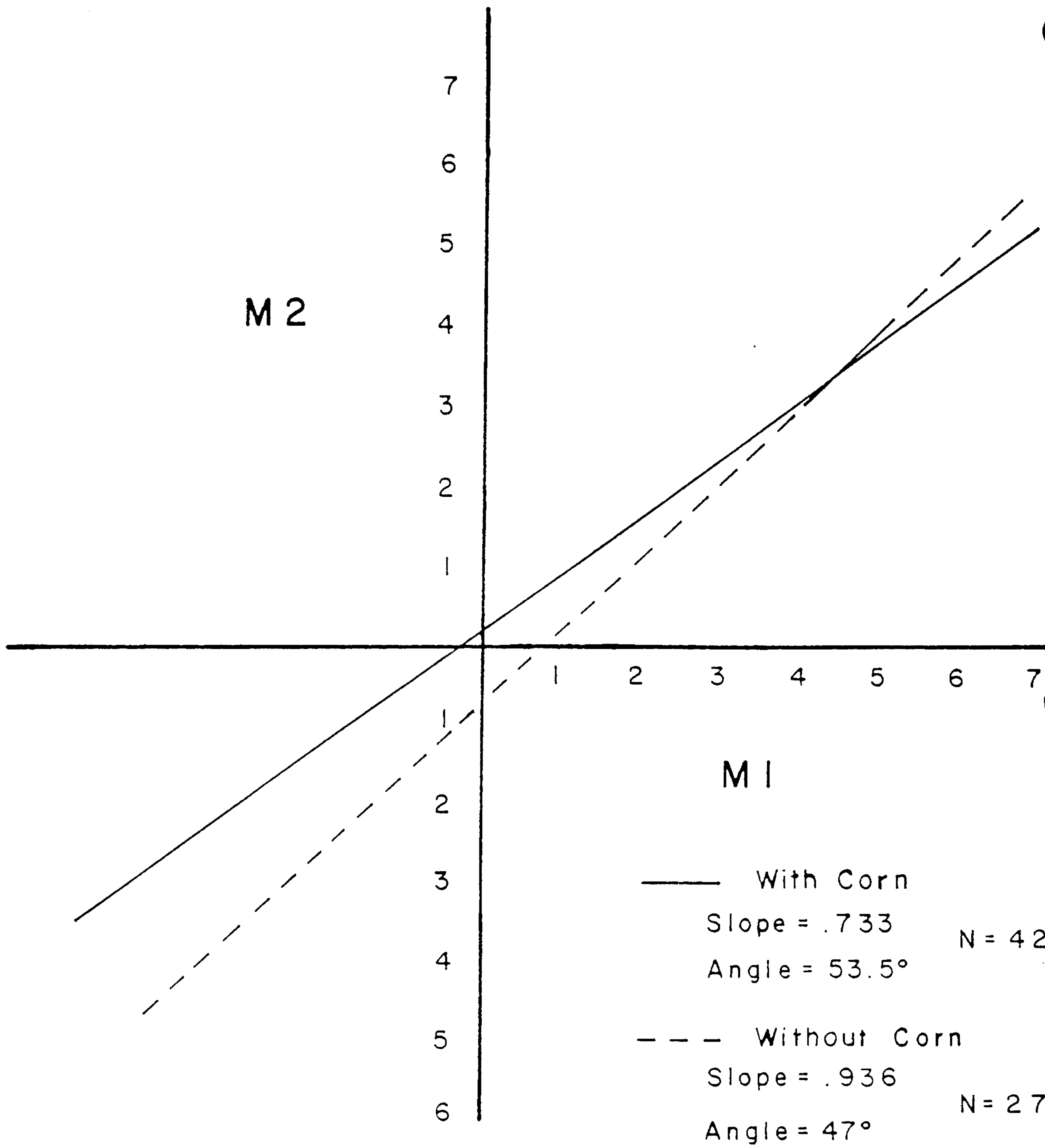

Figure 15. Plot of principal axis for tumuli with corn and tumuli without corn - sexes combined.

those briefly touched upon here will be expanded in the Discussion section. In that section the rate of wear of the southwest Missouri population will be compared with three populations, each of which practiced different subsistence strategies.

Dental and Oral Pathology

The primary purpose of this analysis was to see if those individuals presumably engaged partly in a gardening economy could be distinguished from those presumably involved primarily in a hunting and collecting strategy. The separation might be based upon statistically significant differences in the incidence of caries, abscesses, antemortem loss and periodontal disease, as well as the rate of wear. Further, to investigate combinations of variables that may characterize the groups and to assess the degree of interrelatedness, multiple correlation analysis was conducted on the caries, abscess, and degree of wear data.

The frequency of pathologies by tumuli with corn and tumuli lacking corn is presented in Table 27. Examination of these data show that the few (5) cases of abscessing were confined to individuals from tumuli containing corn while a minutely greater number of antemortem loss occurred from tumuli lacking corn. A single individual in each group, an old male and an old female, respectively, accounted for the lost teeth. Antemortem loss was not helpful in differentiating between the groups. As is obvious from the raw percentages, chi-square (X^2) comparisons of abscessing and of antemortem loss were not significant ($p>.05$).

A higher incidence of caries was observed for individuals from tumuli with corn. The X^2 test demonstrated the difference to be significant at the .01 level ($X^2=7.72$). These results are congruent with the hypothesis of a higher carbohydrate diet leading to an increase in the number of carious lesions, and reproduce similar findings.

At first glance it may seem odd that degree of wear and caries severity from tumuli without corn are significantly associated (Table 28). However, a high or rapid degree of wear speeds the process of occlusal simplicity which progressively leads to obliteration of the food-retaining cracks and fissures in the teeth. As areas favorable to bacterial growth are short-lived, caries formation is impaired. Populations with rapid dental wear usually have fewer caries. The significance then pertains to an inverse association between degree of wear and caries. The occurrence of caries is virtually independent of wear on individuals with corn; caries are associated with neither a low nor a high degree of wear, but rather develop in response to something else. This 'something else' I believe is related to the presence of corn in the diet.

TABLE 27

Incidence of Pathologies By Tumuli With Corn Versus Tumuli Without Corn

	Without Corn	With Corn
Caries By Type		
Occlusal	1	15
Interstitial	2	14
Root or smooth surface	0	0
Total	3	29
Total known teeth	114	232
Per cent caries	2.6%	12.5%
Abscessed Teeth	0	5
Total known teeth	114	232
Per cent abscessed	0%	2.2%
Antemortem Loss	2	1
Total known teeth	114	231
Per cent lost	1.75%	.4%

All teeth for which data were missing were omitted from the calculations.

A relationship between wear and abscessing is suggested by the significant correlation (Table 28). Entry of infection into a tooth socket may be facilitated by a worn tooth or by an alveolar architecture weakened from continued masticatory stress upon an attrited surface.

The results of the assessment of periodontal disease are somewhat misleading (Table 29). The data are based only upon teeth with an alveolus intact enough for observation. This prerequisite eliminated several individuals from the evaluation. Individuals possessing corn do have a greater incidence of periodontal disease but the results of a X^2 test were not significant ($p>.05$).

Table 30 is a summary of the pathological evidence. The presumed gardeners with a higher carbohydrate intake than the presumed hunters and collectors have dentitions that accord well with what was expected. The over-all rate of dental attrition being faster for the hunters and collectors replicates results Scott (1974) obtained from an analysis of Peruvian dentitions.

Dentofacial Metrics

Metrics were compiled from three gnathic sources: the mandibular and maxillary posterior dentition and the orofacial region. The results of each are considered separately in the presentation of each of the three analyses to follow. Thus, three analyses were conducted — Principal Components, Discriminant Function, and Fluctuating Dental Asymmetry — involving three sources of data.

Principal Components Analysis

In all cases, the first unrotated and rotated principal component was definitely size, and the individual factor scores correlated well with the sex of the individual.[7] As discerning differences (should they exist) in individuals from tumuli containing corn and tumuli lacking corn is of prime concern, unrotated Factors 2 and 3 will receive the greatest attention. These factors depict the relative shape, pattern, or proportionate size between teeth, pairs of teeth and orofacial build. Should significant differences be observed, it may be stated that different diets are reflected in the shape of the posterior teeth and orofacial apparatus of prehistoric southwestern Missourians. The degree that differences may be genetic is indeterminate; distortions from a disparate sex ratio are probably minimal as the samples were nearly equal (see Table 8).

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[7] See Appendix IXc-f for data relevant to the principal components analysis.

TABLE 28

Pearson Product-Moment Correlations of Pathological Data

	Caries	Abscess
	Tumuli With Corn	
Caries	-	$N = 232$ $r = .092$ $P > .05$
Abscess	-	-
Wear	$N = 232$ $r = .038$ $P > .05$	$N = 232$ $r = .291$ $P < .05$
	Tumuli Without Corn	
Caries	-	-
Abscess	-	-
Wear	$N = 114$ $r = .193$ $P < .05$	-
	Combined	
Caries	-	$N = 346$ $r = .098$ $P > .05$
Abscess	-	-
Wear	$N = 346$ $r = .068$ $P > .05$	$N = 346$ $r = .262$ $P < .05$

TABLE 29

Teeth Assumed Affected by Periodontal Disease

	Tumuli Without Corn	Tumuli With Corn
LM_3	0	1
LM_2	1	2
LM_1	1	3
LPM_2	1	5
LPM_1	0	5
RM_3	1	2
RM_2	1	1
RM_1	1	3
RPM_2	2	6
RPM_1	2	5
LM^3	0	2
LM^2	0	3
LM^1	2	4
LPM^2	1	3
LPM^1	0	2
RM^3	0	2
RM^2	0	4
RM^1	2	7

TABLE 29: Continued

Teeth Assumed Affected by Periodontal Disease

	Tumuli Without Corn	Tumuli With Corn
RPM^2	1	2
RPM^1	1	2
Total Diseased	17	64
Total Known Teeth*	70	187
Per cent Diseased	24%	34%
Number of Individuals	6	14
Total (N)	10	17
Per cent of Individuals with Periodontal Disease	60%	82%

*Teeth with alveolar structures sufficiently intact for observation.

TABLE 30

Summary of Pathologies

	Tumuli Without Corn	Tumuli With Corn	X^2
Caries rate	Low	High	P <.05
Abscessing	None	Few	P >.05
Antemortem loss	1 individual (2 teeth)	1 individual (1 tooth)	P >.05
Attrition	Faster	Slower	-
	(females with corn > males without corn > females without corn > males with corn)		
Periodontal disease	Present but fewer individuals affected	Present with more individuals affected	P >.05

The eigenvalues for the principal components analysis are included in Appendix IXf. The unrotated factor loadings are interpreted in the analyses below.

Mandibular Buccal-Lingual Diameter

Factor 2 contrasted the molars (M's), being of a different shape, with the premolars (PM's). Individuals from tumuli with corn dominated the positive Factor 2 scores but the mean did not fall outside the range of the other indicating a lack of significance in this information. A student's t-test of the difference in the means of the scores from individuals with corn and without substantiated this lack of significance ($p>.05$).

Factor 3 was just the opposite of Factor 2 depicting the molars, especially the M3's, as differing from the PM's. In accordance with this opposition, negative scores predominantly fell on the presumed gardeners. Although the mean fell beyond the range of the presumed hunters and collectors (unrotated scores only), the student's t-test revealed the groups to comprise a single population ($p>.05$).

Plotting the unrotated individual scores per factor against one another (i.e., Factor 2 on the X-axis with Factor 3 on the Y-axis) displayed a lack of clustering about any point of any consistent group, and a generally wide dispersion of the scores. All in all, nothing of significance nor peculiar to southwest Missouri was disclosed in the principal components analysis of the buccal-lingual diameter of the posterior mandibular teeth.

Maxilla Buccal-Lingual Diameter

Factor 2 was quite similar to the mandibular Factor 3 in that all molars, most markedly the M3's, were of a different shape and pattern than the PM's. The M1's and M2's were definitely alike and differ from the other teeth, especially the PM1's. This was undoubtedly a size and shape difference as rotation presents results combining the effects of both.

As with the mandibular scores, the mean and range of tumuli with corn and tumuli without were plotted. All factor means fell well within the range of one another and the range was markedly similar for several factors. A student's t-test of the difference in the means was computed and found to be insignificant ($p>.05$).

Orofacial Metrics

Maxilla length and mandibular condyle breadth loaded high on Factor 2. The relationship between these two differs

markedly from maxillary breadth. There were no extreme loadings on Factor 3. Differences occurred between condyle length and the other mandibular metrics of length, symphysis height and condylar breadth. Symphyseal height and condylar length were most dissimilar.

Although the means of individuals from tumuli containing corn and those lacking corn were noticeably different in most factors, there was no statistical reason to assume the samples were drawn from separate populations (student's t-test, $p > .05$ for all factors).

Discriminant Function Analysis

A more direct approach in distinguishing the groups, and providing insight into their validity as being dietarily different, is provided by the discriminant function analysis. The analysis assesses the discriminating power of the variables and reveals which variable(s) wield the greatest power (see Benfer 1980). In Table 31 statistics of the analysis for each of the three data sets are given. For clarity and keeping with the format, each parameter is accorded separate presentation.

Mandibular Buccal-Lingual Diameter

It is observed from Table 31 that the chi-square test is significant at the .10 level, suggesting that the probability of individuals belonging to the same population is 1 chance in 10. Much of the discriminating power was due to the left PM's as indicated by the probability values of the F-ratio.[8] The ability shown here to significantly distinguish individuals from tumuli containing corn from those not is unusual. A close look at the original data was required in order to better understand these results. The use of the grand mean as a substitute for missing data provided a conservative estimate of that value when testing against group homogeneity. However, if one or the other group required appreciably more mean estimates, then the results of any analysis would be skewed, but this was not usually the case. For example, considering the left PM's, 3.6% of the total required mean substitution comprising nine individuals. Of these, four were from tumuli with corn while tumuli without corn yielded five. It is doubtful that the use of a mean estimate for missing data distorted the results achieved in any significant way. It can be stated with certainty then, that tumuli with corn held individuals with larger buccal-lingual diameters than individuals lacking corn; such differences could have occurred by chance only 10% of the time (the samples are, in fact, from the same population).

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[8] See Appendix IXg.

TABLE 31

Statistics For the Discriminant Function Analyses

	Mandible	Maxilla	Orofacial
Wilks Lambda =	.426	.328	.867
D.F. =	10 and 14	10 and 5	9 and 5
F-Ratio =	1.887	1.022	.857
P =	.1346	.4770	.6046
Chi-square -	16.219	11.135	8.867
D.F. =	10	10	9
P =	.0949	.3480	.5490

By plotting the individual scores the data are clearly and visibly displayed, and overlap is easily spotted. From Figure 16, two individuals from tumuli lacking corn fall within the spectrum of corn-bearers. Fairfield Mound 2, 23BE6/2, Burial 3 was determined to be a 20-30 year old male. Six of ten of all measurements evaluated were not original values but mean estimate substitutions. Thus, the placement of this individual within the other group is dubious, and possibly an artifact of sampling. The other individual was interred at the Clemons Mound, 23CE122. Burial 2b was a female 25-35 years of age. All of her metrics were original, indicating a genuine similarity between her lower jaw and those of individuals from tumuli containing corn. Her grave was not suggestive of special or selective treatment, being a secondary interment lying within an ossuary with seven other individuals, several of whom were children.

Maxilla Buccal-Lingual Diameter

The posterior maxillary teeth indicated homogeneity among individuals with corn and those without (Table 31 and Appendix IXg). The X^2 test was insignificant ($p>.10$) and the centroids depict the similarity clearly:

	Corn	Without Corn
Centroid	-2.06	-2.24

The individual scores also showed little divergence with the maximum spread being only 30/100's of a point. Thus, unlike their opposing counterpart, the maxillary dentition did not discriminate between the groups.

Orofacial Metrics

This investigation was interesting in that the multivariate results of the tests of the null hypothesis were all insignificant (Table 31), yet a perusal of the F-ratios for simple magnitude differences disclose several to be less than .10, and one (out of nine), coronoid height, differs at the .05 level. It seems that, collectively, the orofacial metrics do not distinguish between groups, although there are some distinctive individual measurements.

The variables helpful in discriminating between groups are all mandibular: breadth of the condyle, height of the coronoid process, and depth of the coronoid notch. Scrutinizing the original data eliminates the culprit of missing data as an explanation for the results. As individuals thought to have supplemented their diet with corn showed significantly larger buccal-lingual diameters of mandibular teeth, especially the PM's, it is not surprising to observe larger mandibular dimensions on these same people. Possibly a larger sample or at least one more equitably distributed

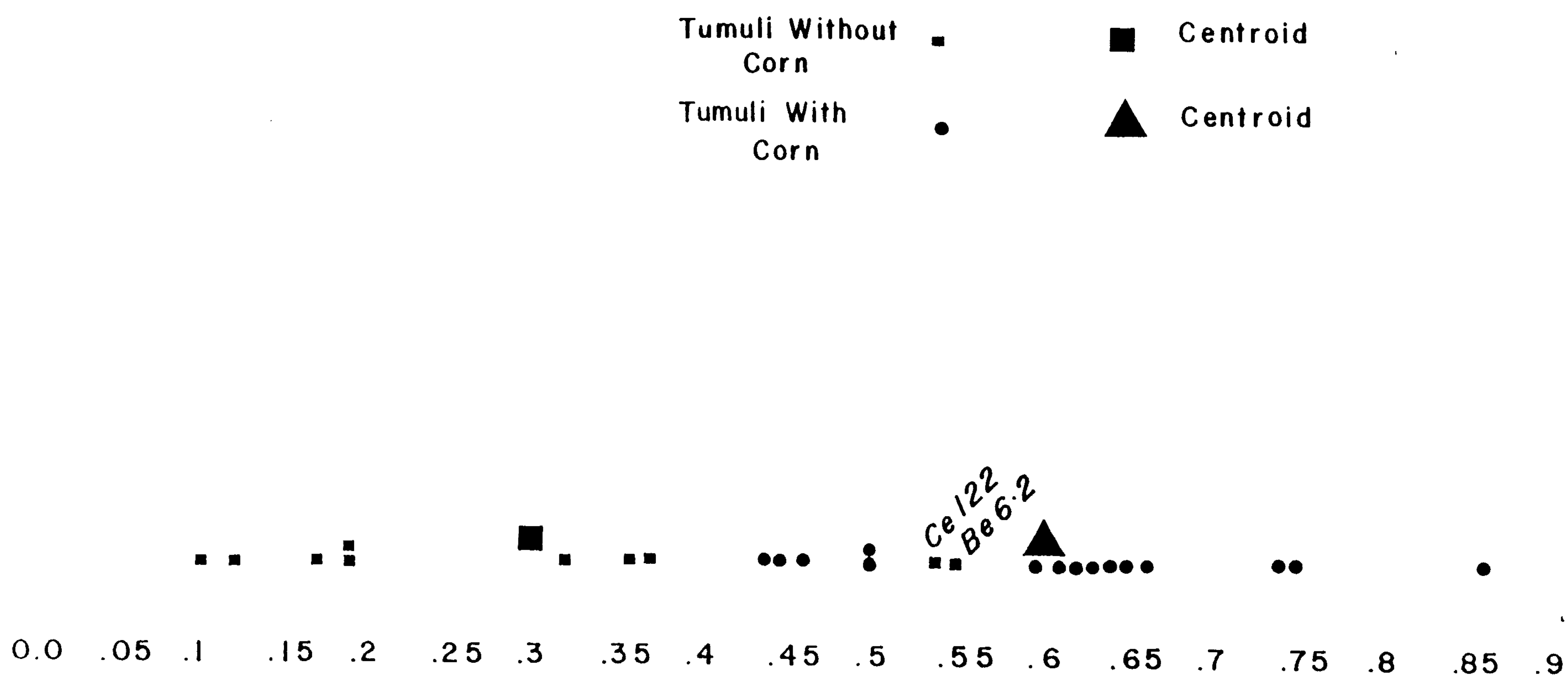

Figure 16. Discriminant functions scores plot of mandibular buccal-lingual diameter.

would have revealed significant differences over-all between these groups.

Fluctuating Dental Asymmetry

High Pearson product-moment correlation coefficients (r) indicate correlation between variables, which in this case are antimeric teeth. Low or insignificant ($p>.05$) values for r denote a lack of covarying or, phrasing it in terms of this study, asymmetry.

Considering each tooth separately, no significant asymmetry was observed among the antimeres of the M1, PM2 and PM1; but the M2 and M3 antimeres were asymmetrical (Table 32). Separation of the sample based upon the presence or absence of corn and assessing only mandibular teeth revealed the M2 and M3 from individuals lacking corn to be significantly asymmetrical (Table 33). Conversely, the molars of the presumed corn-eaters were more symmetrical. Averaging the molar scores did not reveal a significant degree of difference in dental asymmetry between the groups (Table 33) at the .05 level. But, when the Z-values for Wilcoxon's test were computed for the correlation coefficients (r), the difference was significant at the .10 level. In the discussion section to follow, these data are contrasted with two other archeological populations of known and differing subsistence economies, and with a modern cadaver series.

To assess the magnitude of age-related asymmetry and to possibly demarcate the age-group(s) most asymmetrical, the simple arithmetic average molar asymmetry was computed[9] for the southwest Missouri sample (Table 34). Unfortunately, the results cannot be compared with those to follow as both available jaws and groups had to be combined in the Missouri sample. This was necessary to facilitate the formation of a sample of sufficient size for the generation of meaningful results. Significant asymmetry ($p<.05$) is reported for the 18-20 and 31-35 year old group. These results are considered tentative as the sample sizes were quite small for both of these age-groups. It may be of interest to note that two of the 18-20 year olds lacked corn while the older groups were evenly split.

Discussion

The following includes not only a discussion of the results but also cross-cultural comparisons among southwest Missouri and neighboring archeological populations. Of course, these comparisons were possible only when relevant

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[9] The simple arithmetic value was computed for simplicity; the Z transformation should be used for a more precise estimate of central tendency.

TABLE 32

Degree of Asymmetry (r) and Variance
Per Tooth for Entire Series

Tooth	N Pairs	r	Variance of r
M3	21	.77	.62
M2	25	.70	.50
M1	27	.91	.44
PM2	23	.91	.43
PM1	20	.81	.61

TABLE 33

Degree of Asymmetry (r) Among Antimeres and Average Molar Asymmetry With Separation of the Groups

Tooth	Group	N Pairs	r
M3	With corn	11	.90
	Lacking corn	6	.66
M2	With corn	13	.64
	Lacking corn	7	.58
M1	With corn	13	.95
	Lacking corn	9	.71
PM2	With corn	10	.99
	Lacking corn	8	.65
PM1	With corn	10	.84
	Lacking corn	6	.70
Average Molar Asymmetry			
	With corn	37	.77
	Lacking corn	22	.32

TABLE 34

Simple Arithmetic Average of Molar Asymmetry (r) Per Age Group

Age	Female	Male	Pairs of Teeth	Average Molar Asymmetry (r)+
18-20 yrs.	2	1	5	.62
21-25 yrs.	7	2	26	.92
26-30 yrs.	2	2	7	.84
31-35 yrs.	2	0	4	.87
36-40 yrs.	1	2	1	Insufficient data
41+ yrs.	2	4	9	.72

+M3's were omitted from the correlation except for the 21-25 year olds.

data were available. The format is the same: Attritional Rate preceding Dentofacial Metrics, which is separated into the analyses of Principal Components, Discriminant Function, and Fluctuating Dental Asymmetry.

Attritional Rate

Scott (1979b) provides data from the principal axis analysis of three Amerind skeletal samples: Indian Knoll, a Kentucky Archaic population primarily of hunters and collectors with a concentration upon shellfish; the Hardin site, a Ft. Ancient Village in Kentucky which followed a food producing horticultural economy; and the Campbell site, a Mississippian site in southeast Missouri also composed of horticulturists. The mandibles and maxillae were scored separately following the ordinal scales of Molnar (1-8 system) and Scott (4-40 system). Computation of the principal axis was as previously discussed. Comparison of the slopes of these three sites with the southwest Missouri skeletal series was possible with the data scored on the Molnar system as that was the technique used in that analysis. The results of the analysis from southwestern Missouri are presented in Table 26. The placement of these slopes relative to Molnar's scores (Scott 1979: 208, Table 4) for the Indian Knoll, Hardin, and Campbell sites is shown in Table 35.

It is apparent from Table 35 that the rate of wear for the maxillae and mandibles from southwestern Missouri do not coincide. Scott (1979: 207) observed this difference in the Hardin and Campbell sites, and was equally puzzled. She posited dissimilar cusp number and pattern and sex-related cultural practices as possible causes. What is more informative than her suggestions is the fact that the disparate rates were from those particular sites. The southwest Missouri data are most similar to the Hardin and Campbell horticulturists, especially the Missouri Campbell site. A different rate of wear for the upper and lower dentition may be positively correlated with subsistence practice. Such a hypothesis definitely warrants further testing.

The 95% confidence limits are included in Table 26. Comparison of these data with those in Scott's Table 3 for the Indian Knoll, Hardin, and Campbell sites (1979: 206) yield the following similarities:

1. The confidence limits of the Campbell site maxillae encompass the _b_ of the combined maxillae, maxillae with corn, and maxillae without corn. The mandibles with corn _b_ fall within the confidence limits for the Campbell mandibles. Lastly, the confidence limits of all mandibular data overlap the _b_ of the mandibles without corn.

2. Alternatively, the confidence limits of the mandibles without corn encompass the Indian Knoll mandibular _b_; the

TABLE 35

Comparison of Principal Axis Slope

<u>Southwestern Missouri Tumuli Combined</u>

MAXILLAE

	Indian Knoll		Hardin		SW Missouri		Campbell
b =	1.43	>	1.14	>	.685	>	.630

MANDIBLES

	Hardin		Indian Knoll		Campbell		SW Missouri
b =	1.19	>	1.06	>	.870	>	.841

<u>Southwestern Missouri Tumuli Separated</u>

MAXILLAE

	Indian Knoll		Hardin		SW Missouri with corn		Campbell		SW Missouri without corn
b =	1.43	>	1.14	>	.676	>	.630	>	.500

MANDIBLES

	Hardin		Indian Knoll		SW Missouri without corn		Campbell		SW Missouri with corn
b =	1.19	>	1.06	>	.984	>	.870	>	.773

composite mandibles overlap the Campbell mandibular b; and the Campbell maxillae b comes to within 3/100's of falling inside the confidence limits of the maxillae with corn.

3. Over-all, the above indicates the closeness of the Campbell site to the southwest Missouri rate of wear scores.

The mean degree of wear scores in Scott's data were not corrected for age, and are presented merely to provide a general idea of the relative degree of wear among the series. The teeth have a higher mean degree of wear than those from the Hardin and Campbell sites. The tumuli with corn came closest to approximating Scott's results (1979b: Table 3) in the similarity to the Indian Knoll average wear scores. Positing a definite relationship from this likeness may be spurious as the figures were not age-corrected as stated above, and intra-observor error had not been controlled for.

Dentofacial Metrics

Principal Components Analysis

To review, the purpose of the principal components analysis of dentofacial metrics was to elucidate any dietary differences between individuals assumed to be supplementing their diet with corn and those whose subsistence base is assumed not to include corn. Variables of buccal-lingual diameter of the upper and lower posterior teeth and of oro-facial architecture were analyzed. The shape, pattern and proportionate size as derived from a principal components analysis were compared under the hypothesis that such dimensions would be reflective of the diet and masticatory stress placed on the mouth.

A student's t-test of the difference in the means per factor was computed for the two groups. The results were insignificant ($p>.05$) on all factors. Plausible explanations for these results include:

1. The variables analyzed are not modified appreciably <u>during the life of an individual</u> for a dietary difference to be discerned.

2. The variables used are valid indicators of diet but other food items of similar quality and consistency as corn (e.g., nuts) mask any differences that did actually exist. This may have been a population difference or a difference in social status among a population.

3. The variables are valid indicators of diet and the results are genuine: the gardening and hunting/collecting division of individuals is false. Explanations must now be sought for the occurrence of corn in some tumuli while not

TABLE 36

Sex Distribution and Average Age of Individuals Per Group
Mandibular and Orofacial Metrics Analyses

	Containing Corn (N)	Average Age ($\bar{X}$ years)	Lacking Corn (N)	Average Age ($\bar{X}$ years)
Mandible				
Female	8	28.8 ± 9.9	7	30.4 ± 8.5
Male	7	37.5 ± 8.4	3	28.6 ± 12.4
Orofacial				
Female	6	29.3 ± 11.3	3	28.6 ± 7.9
Male	5	36.5 ± 9.9	1	18.5

in others. Season of the year of the burial ritual, as mentioned previously, may be a contributing factor. Others include social dissimilarities that cannot be isolated dentofacially and which cannot be discerned through biological distance studies as the sample is far too meager; or the differential occurrence of corn may reflect a temporal separation among the tumuli.

4. The sample was not large enough to detect relatively small differences.

Discriminant Function Analysis

Mandibular buccal-lingual diameter and particular measurements of orofacial structure displayed an ability to somewhat discriminate individuals presumably eating corn from individuals presumably not. The distinguishing dimension was a tendency toward greater size in the corn group.

As the sex distribution between the groups was uneven (Table 36), the possibility of sex-related causality was tested using chi-square. There was not a significant ($p>.10$) predominance of males in the corn-bearing groups relative to the group lacking corn. The probability of differential effects on intragroup sexual dimorphism was tested on tooth size using a student's t-test of the difference in the means. Sexual dimorphism was not great enough to significantly influence either group ($p>.10$). Although the diameter of a tooth was taken in such a way as to minimize the effect of enamel attrition, the question of the size difference being due to age must nevertheless be considered. If the measurement was distorted by attrition, older individuals would be expected to have a smaller buccal-lingual diameter. However, individuals comprising the sample from tumuli with corn were older than the other group (Table 36), suggesting that age was not a contributing factor. Rate of wear was not significantly faster on individuals lacking corn and, in light of the lack of association between age, sex, and size, the disclosure of larger posterior teeth and certain mandibular dimensions being possessed by individuals with corn is considered genuine.

The increase in tooth size documented for southwestern Missouri is contrary to the hypothesis of structural reduction occurring concomitantly with food production advanced by Brace (1962). Brace was considering the results of evolutionary trends when he proposed his well-known theory of the Probable Mutation Effect (PME). The validity of the PME or mutational drive (see Byles 1972) as a mechanism of change aside, the foregoing results may not be critical evidence against his theory. The length of time thought necessary for selective pressures to become manifest (see Byles 1972) was not available in the southwest Missouri skeletal sample.

As discussed in Chapter I, the currently available archeological evidence suggest the southwest Missouri population represented a relatively short term (approximately 1,000 years), local development. It is possible that a shift to horticulture may increase the stresses upon dentofacial structures rather than reduce them. Scott (1974; 1979a) found an increase in tooth size paralleling increased dependency upon food production in Peruvian materials. However, in the Late Peruvian maize-producing population, tooth size increased more slowly, suggesting that selection for large teeth had diminished. Scott hypothesized that the high carbohydrate diet slowed dental attrition to the delight of bacterial agents, thus permitting an increase in the frequency of caries and periodontal disease. Avoidance of dental pathologies may have prompted selection for dental simplicity, or at least structural stability. Kirveskari, Hansson, Hedegard and Karlsson (1978) found the teeth of modern Skolt Lapps to be larger than those of their 18th century ancestors. They attributed the increase to improvements in nutrition and socioeconomic conditions, rather than selection (see discussion below).

In the studies by Brace and Scott cited above, the question of tooth size was discussed in view of selective pressures occurring over thousands of years rather than being directly related to subsistence; the data from the Lapps (Kirveskari and others 1978) represent 60 generations, and the sample populations expressed a drastically different standard of living. Until more is known about selection agents and until dentofacial size of populations with known subsistence strategies are analyzed for dietary related differences, only tentative explanations can be offered for the slight size difference observed between the southwest Missouri series. Two reasons are advanced but cannot be expanded due to lack of empirical support: (a) tooth size is a result of pleiotrophic selection or other incompletely understood genetic factors (e.g., drift, epigenetic variability); and (b) the difference in tooth size is due to sampling error as the samples were not representative of their parent population.

A dietary explanation regarded as being quite plausible draws on evidence from the native historic inhabitants of southwestern Missouri, the Osage Indians, and on health research. Will and Hyde (1917: 108) relate that the Osage were not avid corn-farmers. They cultivated only about one-third of an acre for each person in the tribe while hunting continued to be the major means of food procurement. By historical inference, the harvested crop was a dietary supplement for the people antedating the Osage as it was for the Osage. Individuals receiving the caloric enrichment fared consistently better than the others and were concomitantly healthier.

Better nutrition and health spurs growth and promotes the bodies development toward the limits of its growth potential. Primate research has revealed a high correlation between average body size and the size of the first and second molars (Gingerich and Schoeninger 1979), and that size differences may imply dietary differences (Corruccini and Henderson 1978). Larger tooth size in humans may, therefore, also indicate over-all larger body build and different diets. The size difference may therefore be attributed to the plastic response of the human body to a variant nutritional status in a population. Observed differences originating from the type of food consumed may signify class rather than cultural distinctions. For those individuals allowed access to the cultigen, corn was a <u>supplement</u> rather than a staple to the diet. Grain was an addition to the nutritional base available to all members of the population, not a substitution or replacement. The greater longevity of individuals from tumuli with corn is direct evidence of their better health.

Fluctuating Dental Asymmetry

Data comparable to southwestern Missouri are provided by Perzigian (1977b), who assessed the degree of fluctuating dental asymmetry among skeletal populations maintaining different socioeconomic and nutritional strategies. His sample derived from three archeological sources and a cadaver series: (1) the Indian Knoll site representing a pre-agriculture Late Archaic group in Kentucky; (2) the Campbell site, a Middle Mississippian population who practiced agriculture in the bottomlands of southeast Missouri; (3) the Larson site, composed of gardeners in the Upper Missouri River valley in South Dakota and representative of the Post-Contact Coalescent Horizon; (4) Cleveland, Ohio Caucasians of the Hamann-Todd cadaver collection extant in the twentieth century. The close similarity of the Campbell and Larson populations permitted their combination forming a single sample of agriculturists. Hence, southwestern Missouri data will be compared against hunting/collecting, hunting/farming, and cadaver populations. The mandibular buccal-lingual data collected by Perzigian (1977b: Table 2) of concern here are included in Table 37. Although Perzigian expressed the magnitude of asymmetry using the correlation coefficient of Spearman's rho, Baggaley (1964: 21-24) demonstrates that Spearman's rho is numerically equivalent to Pearson's r, which was calculated for the southwest Missouri data.

Table 37 indicates that the r's for individuals lacking corn fall consistently below those of the other groups. The Z-values for Wilcoxon's test were computed for the r's and the difference was significant ($p<.05$) even against the r's from Indian Knoll. However, the Indian Knoll sample revealed significantly ($p<.05$) more asymmetry than did the southwest

TABLE 37

Perzigian's Correlation Coefficients (r)
From Three Populations and Southwest Missouri

Tooth	Indian Knoll		Campbell/Larson		Hamann		Southwest Missouri Corn		Southwest Missouri Lacking Corn	
	N	r	N	r	N	r	N	r	N	r
M3	60	.748	78	.870	33	.635	11	.90	6	.66
M2	103	.889	102	.871	36	.729	13	.64	7	.58
M1	117	.786	123	.909	29	.922	13	.95	9	.71
PM2	103	.841	97	.896	43	.854	10	.99	8	.65
PM1	100	.683	83	.870	49	.846	10	.84	6	.70

Missourians with corn by the Wilcoxon's test. As suggested by the mean of the correlation coefficients between antimeres (Table 38), no significant differences were found between Campbell/Larson, Hamann-Todd and the southwestern Missouri sample with corn by the Wilcoxon's test.

To summarize the results, southwestern Missourians without corn were the most dentally asymmetrical; the southwest Missourians with corn were more dentally symmetrical than Indian Knoll, revealing a degree of asymmetry similar to the Campbell/Larson sample. On the basis of significant differences and similarities in degree of fluctuating dental asymmetry, individuals from tumuli containing corn most closely resemble a hunting/farming population whereas those individuals from tumuli lacking corn show a greater amount of asymmetry than Perzigian's most asymmetric population, the Indian Knoll hunter/collectors. This replicates Gehlert's (1979) results where a coastal, very early agricultural group (Paloma) was more asymmetrical than a Highland maize sample (Inca) for 9 of 12 teeth compared ($p<.05$ by Fisher's Exact test).

Conclusions

The primary research question explored in the foregoing account revolved around the presence of corn in some but not all of the tumuli from southwestern Missouri. The implications are so far-reaching (i.e., incipient agriculture to city-states) and encompassing (i.e., social complexity to cultural extinction) that the biological response to the differential occurrence was closely examined. Toward this end, studies were conducted of the dentition through the analyses of the rate of wear, the incidence of oral pathologies, principal components and discriminant function statistics of the dentofacial metrics, and fluctuating dental asymmetry.

It was demonstrated that females collectively had a slower rate of wear than the males. When the sample was separated into individuals from tumuli containing corn and from tumuli lacking corn, the former exhibited a slower rate of wear than the latter. The women from tumuli without corn wore their teeth significantly faster than those with corn, presenting a rate of wear similar to the men with corn. Comparison of the slopes of the principal axes from hunting/collecting and hunting/farming populations, Kentucky Indian Knoll and Missouri Campbell sites respectively, revealed the southwest Missouri series to be more similar to the Missouri Campbell site. Both samples displayed a slower rate of wear than Indian Knoll, with the Campbell population wearing slightly faster than southwestern Missouri. Considering only the mandibles and separating the southwestern Missouri series into individuals with corn and individuals without

TABLE 38

Simple Arithmetic Mean ($\overline{X}$) Correlation Coefficients Between Antimeres

Southwestern Missouri With Corn	Southwestern Missouri Without Corn	Indian Knoll	Campbell/ Larson	Hamann-Todd
.864	.660	.789	.865	.797

revealed that individuals lacking corn fell between the Indian Knoll and Campbell populations, with teeth wearing slower than Indian Knoll, yet faster than Campbell. Individuals associated with corn showed the slowest rate of wear and most closely approximated the rate from the Campbell site. These data are directly corroborated by the degree of fluctuating dental asymmetry between the populations. Asymmetry was similarily marked for individuals comprising the southwest Missouri sample without corn and the Indian Knoll group while a smaller degree of asymmetry was found for the Campbell site and the southwest Missourians with corn. Hence, the results of both analyses, rate of wear and asymmetry, denote a resemblance between the teeth of individuals lacking corn from southwestern Missouri and the hunter/collectors; and between individuals with corn from southwestern Missouri and the hunter/farmers.

That the external parts of the digestive system of these individuals were subjected to dissimilar foods was supported by the incidence of oral pathologies in southwestern Missouri. Significantly more caries occurred on the individuals consuming corn. They expressed relatively more abscessing and a greater percentage of individuals appeared to have suffered from periodontal disease.

The principal components analysis indicated which dentofacial measurements explained most of the covariation, but the variables did not define a dietary complex among the cases. However, mandibular buccal-lingual diameter and particular dimensions of the mandible demonstrated an ability to discriminate between the groups in the discriminant function analysis. Individuals with corn exhibited larger lower jaw structure than did those lacking corn.

The dietary implications of these results are interpreted from the foundation laid in the demographic and burial dynamics analyses: the skeletal series, regardless of the occurrence of corn, represent one interbreeding population. The differences between individuals from tumuli containing corn and from tumuli lacking corn may be attributed to either status distinctions or to a temporal separation between the groups. Social distinctions were not well-defined in southwestern Missouri as demonstrated in Chapter III. Subtle differences in burial treatment were observed, however. Also, it is impossible to totally exclude from consideration the possibility of differential access to corn. Verification of a gradual realization and acceptance of corn domestication through time requires reliable, absolute dates. Such dating is currently unavailable. The following facts cannot be disputed:

1. The similarity of the southwest Missouri group lacking corn to a population known to have maintained a hunting/collecting economy.

2. The resemblance of the group with corn to a population known to have produced food but not to the abandonment of hunting/collecting activities.

3. Quantifiable differences in dentofacial size between individuals from tumuli where corn was recovered and from tumuli where corn was not recovered.

CHAPTER V

CONCLUSIONS

The research presented here has been a systematic approach to a biological study of a mortuary population. A systems approach requires investigation of as much of the full range of human behavior as is possible from the available data. Assessment of the biophysical constructs of prehistoric mortuary activity within southwestern Missouri from human skeletal remains involved investigations of demography, burial practices, the orofacial complex, and health. Interpretation of these constructs were directed toward a prudent response to the question posed at the beginning: What was the nature of the development and adaptation of the aboriginal population in the central Osage River Basin region of southwestern Missouri? Two issues were realized to be crucial and became the foci in seeking a response to that question: (1) What significance did the occurrence of corn have in prehistoric southwestern Missouri, and (2) Are the biological data supportative of the scheme of cultural dynamics of prehistoric southwestern Missouri postulated from the archeological evidence?

The burial tumuli yielding the skeletal series used in this study were dated on artifactual inclusions (Goldberg 1980) to the Woodland and Mississippian periods (see Roper 1979 for discussion of southwestern Missouri 'Woodland'). The human skeletons from these tumuli provided the opportunity to assess the impact of the advent of corn as a dietary component upon the population.

The available archeological evidence suggests that cultural homogeneity, if not subsistence homogeneity, existed throughout southwestern Missouri beginning at least from Late Archaic times until historic Euro-American contact. The implied continuity and stability may have been maintained by a lack of the necessary economic resources requisite in supporting population and cultural expansion; and by the established, successful adaptation to the resources that were available. The adaptation was primarily a hunting and collecting strategy practiced by small, mobile groups of people, with some food production towards the end of the period.

Significance of Corn

The results of the analyses conducted do not permit a biological or cultural separation of the group of individuals from tumuli containing corn from the group of individuals

from tumuli lacking corn. Statistically significant differences were observed only in a greater incidence of infectious disease for individuals with corn, and certain mandibular and dental metrics which discriminated between the groups. However, over-all mortality was not significantly different between the groups and a dietary complex capable of distinguishing the groups was not defined.

An estimate of the relative impact of corn upon the population was developed. Considering the rate of dental attrition and fluctuating dental asymmetry, the group of individuals associated with corn was found to be most similar to a population practicing primarily a hunting/collecting strategy, but who are known to have supplemented their diet with corn (the Missouri Campbell site). On the other hand, individuals without corn revealed attritional rate and dental asymmetry values approximating those of a predominantly hunting/collecting people (the Kentucky Indian Knoll series). Social distinctions as determined from burial treatment were not well-developed; egalitarianism appeared to be the most probable form of social structure. Differential access to corn based upon community status was, therefore, unlikely. The results, then, are suggestive of corn being a supplementary rather than a staple food in prehistoric southwestern Missouri.

People incorporating tumulus construction into their mortuary behavior occupied the region continuously for about 800 years. During those 800 years, progressive events such as intensive horticulture, rapid population growth, and extensive trade networks, were occurring in neighboring areas, i.e., northeastern Oklahoma and the Illinois River Valley. Certain artifactual inclusions in the tumuli assure us that the southwest Missourians were cognizant of these events. As a matter-of-fact, the concept of mounded cemeteries may have originated from outside contact (Goldberg 1980).

The hypothesis advanced here explains the seemingly confusing results of a pervasive similarity between the groups with and without corn, coupled with a few skeletal dissimilarities that must be meaningful. The postulate considers both the role of corn as a dietary supplement and the temporal continuity of the prehistoric population of southwestern Missouri. It is hypothesized that a single, indigenous population, biologically and culturally adapted to southwestern Missouri habitat, acquired knowledge of corn at some point in its history. The utilization of corn exerted no observable influence upon the social or settlement systems, but the nutritional impact caused skeletal and gnathic changes in the human frame. As the biological modifications were not inclusive or of great magnitude and as the social structure and settlement complexity were

unaffected, the contribution of corn to the diet was supplemental to the existing hunting/collecting adaptation.

Biocultural Dynamics

The biological analyses and the evaluation of mortuary practices substantiate the cultural construction postulated from the available archeological evidence for southwest Missouri. Thus, the current biological and cultural evidence has argued that the Ozark Highland and Western Prairie Regions of southwestern Missouri nurtured an indigenous population, maximally adapted, and culturally conservative with little penetration by outside populations.

Perhaps these conclusions should be qualified with the word "tentative." However, the rigor exercised in this study and the concordance of these conclusions with those from an independent analysis of the archeological data from the same tumuli (Goldberg 1980), plus the corroboration from settlement, site-catchment, and environmental sources, justify an air of confidence.

APPENDICES

APPENDIX I

TABLE 39

Descriptions of Excavated Tumuli from Southwest Missouri

Number	Mound/ Cairn	Physiographic Location	Tumulus Dimensions (ft)		Tumulus Shape	Disturbance	Excavator	Cremation[1]			Site Report		Re-evaluation	
			Mean Diameter	Height				Present	# of Individuals	In Situ	Discrete	Broadcast	Discrete	Broadcast
HI 135	M	Ridge crest	26.5	1.0	Dome	5' by 5' into bedrock 3'	Wood, 1961	No	0	..	1	0	1	0
PO 305	M	Ridge crest	28.5	1.3	Oval	Extensive	Wood, Pangborn	Yes	1	No	2	0	1	0
CN 13	C	Hill crest	15.0	1.5	Dome	4.5' by 2' Extending to bedrock	Marshall 1956	Yes	..	Yes	8	2	..	..
CE 148	M	Bluff top	19.0	1.5	Circular	None	Wood, Pangborn	Yes	7	?	7	15	11	7
CE 150	M	Bluff top	21.0	1.5	Elliptical	None	Wood, Pangborn	Yes	3	?	8	2	11	1
CE 152	M	Hill crest	21.5	1.5	Elliptical	None	Wood	Yes	3	No	3	3	2	5
CE 154	M	Hill side	17.0	0.5	Oval	None	Wood	Yes	2	?	2	1	1	2
DA 222	M	Bluff top	16.5	1.0	Dome	None	Wood	Yes	6	No	5	5-6	4	7
DA 225	M	Bluff top	21.0	1.0	?	Minor	Wood	Yes	3	?	7	6-7	9	4
DA 226	M	Bluff top	23.0	1.0	?	Surface-burials undisturbed	Wood	Yes	3	No	13	6	9	4
DA 246	M	Hill crest	20.0	3.0	Circular	8' in dia. to just above bedrock	Wood, Pangborn	Yes	6	?	15	5	4	6
PO 306	M	Ridge crest	20.0	1.0	Circular	?	Wood	Yes	6	No	11-12	5	10	4
BE 6-1	M	Hill side	28.5	1.5	Hemisphere	Surface-burials undisturbed	Wood 1967	Yes	3	No	5	8	8	3
BE 6-2	C	Hill side	33.0	2.0	Dome	Central	Wood 1967	Yes	3	?	9	4	12	2
BE 6-3	C	Hill side	39.0	2.0	Dome	5' wide and 2' into bedrock	Wood 1967	Yes	3	?	0	5	3	1
BE 6-4	M	Hill side	20.0	1.0	?	10' by 5' to bedrock	Wood 1967	Yes	2	No	3	4	4	1
BE 3	M	Ridge crest	23.0	1.5	Circular	Minor	Wood 1967	Yes	4	?	4	6-7	5	4
BE 128	M	Ridge crest	15.0	1.0	Circular	Center to bedrock	Wood 1967	Yes	3	?	4	6	5	1
BE 112	C	Ridge crest	19.0	1.0	Oval	Minor	Wood 1967	No	..	?	1	..	..	..

APPENDIX I

TABLE 39: Continued

Descriptions of Excavated Tumuli from Southwest Missouri

Number	Mound/ Cairn	Physiographic Location	Tumulus Dimensions (ft)		Tumulus Shape	Disturbance	Excavator	Cremation[1]			Site Report		Re-evaluation	
			Mean Diameter	Height				Present	# of Individuals	In Situ	Dis-crete	Broad-cast	Dis-crete	Broad-cast
BE 117	M	Ridge crest	20.0	1.0	Hemisphere	None	Wood 1967	Yes	3	?	1	4	1	4
BE 118	M	Bluff top	18.5	1.0	Dome	3.5' dia. surface only	Wood 1967	Yes	1	?	1	1	2	0
BE 135	M	Ridge crest	18.5	1.0	Oval	5' dia. nearly to bedrock	Wood 1967	Yes	3	?	4	3	5	2
BE 136	M	Ridge crest	19.0	1.0	Circular	None	Wood 1967	Yes	5	No	5	3	2	6
CE 104	C	Ridge crest	18.0	1.0	?	?	Bradham 1963	Yes	2	Yes	11	0	2	2
CE 122	M	Ridge crest	18.0	1.0	Circular	?	McMillan 1968	Yes	2	No	1	6	11	3
CE 190	M	Bluff top	20.0	1.5	Circular	Extensive	McMillan 1968	Yes	2	?	1	1	1	3
CE 198	M	Hill side	17.0	0.8	?	None	McMillan 1968	Yes	2	No	0	3	0	3
DA 201	M	Bluff top	19.0	2.0	Circular	Center	Wood 1967	Yes	1	?	4	3	3	3
HE 139	M	Ridge crest	15.5	0.7	Oval	None	Wood 1967	Yes	2	?	6	1-2	6	2
HI 30a	M	Ridge crest	40.0	1.5	?	Extensive	Bray 1963	Yes	..	?	1	1	..	..
HI 30c	M	Ridge crest	22.5	1.0	?	Extensive	Wood 1961	Yes	1	?	0	?	0	3
HI 149	M	Bluff top	14.0	1.0	Oval	2 large holes	Wood 1961	Yes	0	?	1	0	4	0
HI 209	M	Ridge crest	14.0	0.5	Hemisphere	None	Wood 1967	No	..	No	6	2	..	..
SR 111	M	Bluff top	18.0	1.0	Circular	Extensive	Wood 1967	Yes	2	?	?	2	0	2
SR 135	C	..	18.0	2.0	..	..	Chapman 1965	..	..	..	..	..	..	..
SR 138	M	Bluff top	25.0	1.5	Hemisphere	Into bedrock large central hole	Wood 1967	Yes	2	?	4	2-3	2	3
SR 141	M	Hill crest	13.0	1.0	Circular	6' dia. extensive	Wood 1967	Yes	0	No	1	2	1	0
HE 150	C	Ridge crest	25.0	1.5	Oval	Minor	Falk 1974	Yes	3	?	6	0	2	3
HE 148-1	C	Ridge crest	18.0	1.0	Circular	Center	Falk 1974	Yes	..	?	1	1	..	..

APPENDIX I

TABLE 39: Continued

Descriptions of Excavated Tumuli from Southwest Missouri

Number	Mound/ Cairn	Physiographic Location	Tumulus Dimensions (ft) Mean Diameter	Height	Tumulus Shape	Disturbance	Excavator	Cremation[1] Present	# of Individuals	In Situ	Site Report Dis-crete	Broad-cast	Re-evaluation Dis-crete	Broad-cast
CE 123	C	Ridge crest	25.0	2.5	?	Fairly extensive	Chapman, Pangborn 1963	Yes	4	No	4	1	5	5
PO 300	M	Hill crest	23.0	1.5	Dome	5' dia. 6"-8" deep	Wood	Yes	7	?	12-13	4-5	9	3
PO 301	C	Ridge crest	23.5	1.5	Oval	Into bedrock 2' extensive	Wood	Yes	2	No	?	2	0	2
PO 307	M	Bluff top	20.0	1.5	Circular	5' dia. 1' deep center	Wood	Yes	5	No	6	7	7	3
HI 18	C	Hill crest	25.0	2.0	?	Extensive	Wood 1961	?	0	?	?	?	0	2
HI 30	C	Ridge crest	35.0	3.0	Hemisphere	Extensive	Wood 1961	Yes	1	?	?	?	1	3
HI 208	C	Ridge crest	37.0	1.0	Circular	Burial undisturbed	Bray 1963	No	..	No	1	0	..	..
PO 304	C	Ridge crest	20.0	1.5	Circular	Center hole	Wood	Yes	1	?	3	1	4	0
DA 250	M	Bluff top	19.0	1.0	Circular	Extensive	Wood, Pangborn 1968	No	0	No	4	0	4	0
DA 216	C	Bluff top	19.0	2.0	?	Extensive	Wood	Yes	1	No	?	1(?)	0	1
DA 237	C	Bluff top	15.5	1.5	Hemisphere	Large central	Wood	Yes	1	?	1(?)	0	0	1
DA 219	M	Ridge crest	21.0	1.5	Hemisphere	5' dia. center base undisturbed	Chapman 1963; Wood n.d.	Yes	2	Yes	3	5	6	4
BE 137	C	Ridge crest	18.0	1.0	Oval	None	Wood, Pangborn	Yes	2	?	2	0	3	1
HE 147	C	Ridge crest	18.0	1.0	Circular	None	Falk 1969	Yes	2	No	2	2	5	1
BY 365	C	..	..	..	..	..	Marshall 1965	..	..	..	..	..	..	..
PO 165	C	Ridge crest	25.0	3.0	Circular	5' by 5' to base	Wood 1961	Yes	1	?	1	1	2	1
DA 221	M	Bluff top	19.0	1.5	Hemisphere	Surface	Wood, Pangborn 1968	No	0	No	1	0	1	0

-(minus) = No
+(plus) = Yes
.. = Unknown
? = Uncertain

[1]Determination of number of individuals made by author; <u>in situ</u> determination made by excavators.

APPENDIX II

TABLE 40

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
Wray-Martin 1	1	I	Lower 20's
	2a	M	35-40
	2b	F	Adult
	2c	I	7-8
	3	I	4-5
	A	F	Lower 20's
	B	M	Adult
	C	I	Adult
	D	I	Adult
Wray-Martin 2	1	M(?)	40-45
	2	F	23-28
	3	I	12-15
	4	I	6-8
	5	I	< 2
	A	I	Adult
Fairfield 1	1*	F	20-25
	2a	M	40-45
	2b	F	18-20
	2c	I	6-8
	3	I	.5-1
	4	I	1.5-2
	5	F	Adult
	6	M	Adult
	A	I	3-5

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From
Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
	B	I	Adult
	C	I	Adult
Fairfield 2	1a	M	22-27
	1b	M	45-50
	2	F	Adult
	3	M	20-30
	4	M	25-35
	5	M	45-50
	6	M(?)	25-35
	7	I	10-12
	8a	I	1.5-2
	8b	I	1.5-2
	9	I	6-8
	10	I	18-19
	A	F	Adult
	B	I	Adult
Fairfield 3	1	I	35-40
	2	I	11-13
	3	I	3-5
Fairfield 4	1	F(?)	30-35
	2	M(?)	45-50
	3	I	1.0-1.5
	4	I	9-10
	A	I	Adult

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
Karr's Camp	1	M(?)	45-50
	A	I	45-50
	B	I	20-30
	C	I	9-10
	D	I	< 6
Devil's Bluff	1	I	11-15
	2	I	Adult
Melanin 1	1	I	6-7
	2a	F	20-25
	2b	M	40-50
	3	M(?)	40-50
	4	I	1-3
	A	I	15-17
	B	I	Adult
Melanin 2	1a	F	20-25
	1b	M	45-50
	A	I	40-50
	B	I	15-17
	C	I	Adult
	D	I	< 1
	E	I	2-5
	F	I	8-12
Monteverdi	A	I	Adult
	B	I	Younger adult

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
Magistrate Bluff	1a	F	45-50
	1b	M(?)	20-30
	A	I	Adult
	B	I	Adult
	C	I	15-17
Briley Creek	1	I	18-20
Simmons	1	M	25-30
	2	I	18-20
	A	I	6-8
Clemons	1	M(?)	40-50
	2a	M	30-35
	2b	F	25-35
	2c	M	20-30
	2d	I	1.0-1.5
	2e	I	4-5
	2f	I	5-5.5
	2g	I	7
	3a	F	Adult
	3b	I	6-6.5
	3c	I	12-14
	A	M	45-50
	B	I	6
	C	I	Adult

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
Broyles	1	I	1.5-2.5
	2	I	3.5-4
	3a	I	9
	3b	I	1-1.5
	3c	I	3
	A	I	Adult
	B	I	< 1
	C	I	Adult
	D	I	Adult
	E	I	Adult
Amity	1	F(?)	Adult
	A	I	Adult
	B	I	< 6
	C	I	Child
Alberti	A	I	< 3
	B	I	Adult
	C	I	Adult
Murelle 1	A	F(?)	Adult
	B	I	Adult
Mt. India	1	M	45-50
	A	I	Adult
	B	I	1-2
	C	I	8-9

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
Cave Knob	1	M(?)	35-40
	2	I	12-14
	3	F	20-30
	4	I	2-3
Mandrake	1a	F	18-19
	1b	M	30-35
	1c	I	1-2
	2	F	18-20
	3	M	35-40
	4	I	Adult
	5	I	Adult
	A	I	Adult
Morgan	1	F(?)	40-50
	2	M	45-50
	3	I	7
	A	I	12-13
	B	I	18-20
	C	I	30-35
Eckhardt	1	F	22-28
	2	M	18-19
	A	I	10-11
	B	I	20-25
	C	I	40-50

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From
Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
Lytle	A	I	45-50
	B	I	30-35
Eureka**	2	F	20-25
	3	I	4-5
	4	I	Adult
Holbert Bridge	1	I	20-25
Gobbler's Knob	1	F(?)	30-40
	2	F	20-30
	3a	I	3-5
	3b	I	.5-1
	4	M(?)	35-50
	A	I	Adult
Star Ridge	1	I	7-8
	2	I	25-30
	A	I	Adult
Colline	1	I	Adult
Umber Point+	1	F	35-45
	2	M	45-50
	3	I	Newborn
	4	I	0-.5
	5	I	.5-1.5
	6a	F	35-45
	6b	M	35-45
	7	I	Adult

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
	8	I	1.5-2.5
	9	I	1-1.5
	10	I	0-.5
	A	I	8-12
	B	I	6-10
	C	I	Adult
	D	I	Adult
	E	I	Adult
	F	I	Adult
	G	I	Adult
Sorter's Bluff+	1a	F	20-25
	1b	I	.5-1
	2	M	12-17
	3	M(?)	20-25
	4	M	30-40
	5	I	.5-1
	6	M	25-35
	7	M	35-45
	8	I	3-4
	9	I	3-4
	10	M(?)	40-45
	A	I	Adult
Bowling Stone+	1a	M	40-50
	1b	I	16-25

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
	A	I	0-.5
	B	I	1-2
	C	I	12-13
	D	F	25-30
	E	I	Adult
Sycamore Bridge	1	M	20-23
	A	I	20-25
	B	I	Adult
Tunnel Bluff+	1	I	10
	2a	I	5-7
	2b	F	Adult
	2c	M	15-17
	A	I	Fetal-newborn
	B	I	.5-1.5
	C	I	2.5-3.5
	D	M	Adult
	E	F	Adult
	F	I	Adult
	G	I	Adult
Bunker Hill+	1	F	20-25
	2	I	7-8
	3	F	Adult
	4	I	3-4
	5	I	2-3

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
	6	I	7-8
	7a	F	30-40
	7b	M	30-40
	8	I	1-1.5
	A	F	Adult
	B	M	Adult
	C	I	Adult
	D	I	Adult
	E	I	Child
Divine+	1	M	40-45
	2	F	Adult
	3a	M	Adult
	3b	F	Adult
	3c	I	3
	4a	M	35-40
	4b	M	25-35
	4c	F	45-50
	4d	I	8
	A	I	Child
	B	F(?)	Adult
	C	I	Adult
	D	I	Adult
Paradise Tree+	1	I	3-4
	2	M	16-17

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
	3	F	30-35
	4	F(?)	40-45
	A	I	Adult
	B	I	Adult
	C	M(?)	Adult
	D	I	Adult
	E	I	0-.5
	F	I	Child
Slick Rock+	1	I	1-2
	2	F(?)	Adult
	3	I	10-13
	4	M(?)	45-50
	5a	F	20-25
	5b	F	18-20
	6a	F	20-21
	6b	F	25-35
	7	I	.5-1
	8	M(?)	5-10
	A	M	Adult
	B	M	Adult
	C	I	Adult
	D	I	Child
Madrigal+	1	F	55+
	2	M	45-50

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From
Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
	3	F	15-16
	4	M	13-15
	5	I	15
	6	M	20-30
	7	I	30+
	8	F	45-50
	9	I	8
	A	I	Adult
	B	I	.5-2
Petit Cote	1	I	Adult
	2	I	Adult
King's Curtain+	1	I	1-4
	2	M(?)	35-40
	3	I	6-7
	4a	F	45-50
	4b	M(?)	15-18
	5	F(?)	12
	A	I	20-30
	B	I	35-45
	C	I	Subadult
Barren	1	F	35-45
	2a	F	30-40
	2b	I	2-5
	A	I	Adult

APPENDIX II

TABLE 40: Continued

Age and Sex Distribution of Skeletons From Southwestern Missouri Burial Tumuli

Tumulus	Burial	Sex	Age in Years
Matthews[+]	1	I	2-4
	2	I	4-6
	3	I	25-30
	4	I	25-30
	5	F	45-50
	6	M	45-50
	A	I	8-10
	B	I	10-11
	C	I	25-35
	D	I	20-25
Cordwood	1	F	8-9
	2	M	8-9
	3	I	30-40
	4	I	2-3
Sand Bluff	A	I	20-30
Turnback	1	I	Adult
Comstock	1	F	25-30

[+]Tumuli containing corn

*Intrusive not utilized in life tables

**Burial 1 presumably removed by potters (Wood & Pangborn 1968)

APPENDIX III

RAW DATA

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			HUMERUS						ULNA				RADIUS			PATELLA	
Tumuli	Burial	Side	Maximum Length	Maximum Head Diameter	Proximal end Breadth	Distal end Breadth	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Length	Shaft Length	Trochlear Notch Height	Distal End Breadth	Length	Maximum Head Diameter	Distal End Breadth	Maximum Height	Maximum Breadth
								FEMALES									
PO 300	1	R	-	-	-	-	-	-	-	-	25.2	-	-	-	30	33.6	36.7
	1	L	-	-	-	53+	-	-	247	230	23+	11.4	23.1	18+	-	-	-
PO 307	4A	R	-	-	-	-	19+	18+	-	-	-	-	-	-	-	-	-
	4A	L	-	-	-	-	17.5+	16.5+	-	-	-	-	-	-	-	-	-
DA 250	2	R	300	-	-	-	-	-	-	-	-	-	-	18	-	34.3	33
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	35	31
DA 219	5	L	313*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 221	1	R	305	41	24	55	18	19	-	-	-	16.7	-	-	-	-	-
		L	-	40	23.3	-	-	-	236	214	23	15.7+	-	-	-	-	-
CE 150	1A	R	315*	-	-	53.7	18.6	17.3	255.8+	236	21.1	-	-	-	29.6	-	-
	1A	L	315*	40.3	-	52.7	19	17.3	-	-	-	-	228.7	18.2	30.1	-	-
DA 222	2B	R	318*	-	-	-	-	-	-	-	-	-	237	21	-	-	-
	2B	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 225	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	R	301+	-	24.3	-	21.3	20	255+	235	24.2	-	-	-	-	-	-
	3	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 226	2	R	-	-	-	-	-	-	-	-	-	-	-	-	-	39	39.3
	2	L	-	-	-	-	-	-	-	-	-	14.3	-	-	30	37	37.2

+Approximate
*Steele

APPENDIX III a

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			FEMUR									TIBIA							SACRUM	
Tumuli	Burial	Side	Length	Bicondylar Length	Trochanteric Length	A-P Sub-trochanteric diameter	M-L Sub-trochanteric Diameter	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Maximum Head Diameter	Epicondylar Breadth	Length	Physiological Length	Maximum Diameter Proximal End	Nutrient Foramen A-P Diameter	Nutrient Foramen M-L Diameter	Fibula Length	Clavicle Length	Height	Breadth
											FEMALES									
PO 300	1	R	410+	-	-	23.3	31	-	-	41.7+	-	-	-	-	32.4	19	-	-	-	-
	1	L	-	-	-	23.6	32	-	-	-	-	-	-	-	-	-	-	-	-	-
PO 307	4A	R	-	-	-	26	27	27.2+	23+	-	-	-	-	-	-	-	-	-	-	-
	4A	L	-	-	-	-	-	22+	23+	-	-	-	-	-		-	-	-	-	-
DA 250	2	R	406	392	369	21.5	30	23	23	39	72.5	318.8	-	60.2	29	20	318.8	-	-	-
	2	L	394+	-	-	21.3	30	24.4	22	39	-	318.8	-	-	29.3	19.7	318.8	-	-	-
DA 219	5	L	-	-	-	-	-	-	-	-	-	-	--	-	-	--	-	-	-	-
DA 221	1	R	413	407	400	30	28	23.7	27.6	46	-	335	330	66.7	33	22.4	-	-	88	118
	1	L	-	-	-	-	--	-	-	-	79	334	330	71	32.4	22.4	325	135	-	-
CE 150	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	127	-	-
	1A	L	-	-	-	-	-	-	-	-	-	-	-	-	30	19	-	-	-	-
DA 222	2B	R	414*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B	L	422*	-	-	24	30.8	-	-	42	-	-	-	-	-	-	-	-	-	-
DA 225	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	36.4	24	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	R	-	-	-	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 226	2	R	428*	-	-	28	34.4	-	-	45+	-	-	-	-	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

+Approximate
*Steele

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			HUMERUS						ULNA				RADIUS			PATELLA	
Tumuli	Burial	Side	Maximum Length	Maximum Head Diameter	Proximal end Breadth	Distal end Breadth	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Length	Shaft Length	Trochlear Notch Height	Distal End Breadth	Length	Maximum Head Diameter	Distal End Breadth	Maximum Height	Maximum Breadth
DA 226	3B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3B	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4C	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4C	L	320^*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE 148	1	R	303^*	-	-	-	-	-	-	-	-	-	-	17	-	-	-
	1	L	-	-	-	-	-	-	-	-	17.5	-	-	-	-	-	-
	6A	R	-	-	-	-	-	-	-	-	-	15	22.4	-	31.4	-	-
	6A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO 306	5A	R	290^+	36.3	21	-	18	15	252^+	222	18.6	-	233^+	18.8	-	35.7	35.7
	5A	L	-	-	-	53.7	-	-	-	-	19	-	-	17^+	-	-	-
	5B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	35	34
	5B	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6A	R	303	40	22.2	54.3	18.9	18.3	-	-	-	-	-	-	-	-	
	6A	L	-	-	-	-	18.9^+	18.2^+	-	-	23	-	-	-	-	38	36.2
DA 246	3	R	-	-	-	-	-	-	-	-	-	-	-	-	-	37	33
	3	L	307^*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	R	-	-	21.4	-	-	-	-	-	-	14.6^+	-	-	28	-	-
	4	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 128	2	R	-	-	-	-	-	-	-	-	19.7	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Steele
\+ Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			FEMUR									TIBIA							SACRUM	
Tumuli	Burial	Side	Length	Bicondylar Length	Trochanteric Length	A-P Sub-trochanteric Diameter	M-L Sub-trochanteric Diameter	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Maximum Head Diameter	Epicondylar Breadth	Length	Physiological Length	Maximum Diameter Proximal End	Nutrient Foramen A-P Diameter	Nutrient Foramen M-L Diameter	Fibula Length	Clavicle Length	Height	Breadth
DA 226	3B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3B	L	-	-	-	-	-	-	-	-	-	-	-	-	35^{+}	24	-	-	-	-
	4C	R	-	-	-	-	-	-	-	-	-	-	-	-	36.4	23	-	-	-	-
	4C	L	-	-	-	-	-	-	-	-	-	-	-	-	34	22.5	-	-	-	-
CE 148	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	21	19.7	-	-	35	-	-	-	-	-	-	-	-	-	-
	6A	R	427^{+}	-	-	23.2	31.6	-	-	42.3	-	-	-	-	-	-	-	-	-	-
	6A	L	-	-	-	-	-	-	-	-	-	-	-	-	34.5	21.5	-	-	-	-
PO 306	5A	R	-	-	-	21	31.8	-	-	39^{+}	-	325^{+}	-	-	30	19.6	-	-	-	-
	5A	L	-	-	-	21.7	31	-	-	40	-	-	-	-	-	-	-	-	-	-
	5B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5B	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6A	R	-	-	-	23.2	31	24^{+}	23^{+}	42	-	-	-	-	32	22	-	-	-	124
	6A	L	413	410	394	24	30.7	26	24	42	-	-	-	61^{+}	31.2	21.2	-	-	-	-
DA 246	3	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	L	360^{*}	-	-	22.6	28.1	-		-	-	-	-	-	-	-	-	-	-	-
	4	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 128	2	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Steele
+Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			HUMERUS						ULNA				RADIUS			PATELLA	
Tumuli	Burial	Side	Maximum Length	Maximum Head Diameter	Proximal end Breadth	Distal end Breadth	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Length	Shaft Length	Trochlear Notch Height	Distal End Breadth	Length	Maximum Head Diameter	Distal End Breadth	Maximum Height	Maximum Breadth
BE 3	2B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B	L	305*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 135	2A	R	317*	-	-	-	-	-	-	-	21	-	-	-	-	-	-
	2A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 136	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1A	L	-	-	-	-	-	-	-	-	25	-	-	-	-	-	-
SR 138	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE 122	3A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3A	L	315*	-	-	-	-	-	-	-	20+	-	-	-	-	-	-
HI 149	3	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 139	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1A	L	324*	-	-	-	19.8+	18.9+	-	-	-	-	-	-	-	-	-
BE 6-1	4	R	-	-	-	-	-	-	-	-	20.2	-	-	-	-	-	-
	4	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-2	2	R	321*	41.7	25	60.7	-	-	-	-	-	-	-	-	-	-	-
	2	L	-*	-	24.2	60	-	-	-	-	-	-	-	-	-	-	-
BE 6-4	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Steele
+ Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			FEMUR									TIBIA							SACRUM	
Tumuli	Burial	Side	Length	Bicondylar Length	Trochanteric Length	A-P Sub-trochanteric Diameter	M-L Sub-trochanteric Diameter	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Maximum Head Diameter	Epicondylar Breadth	Length	Physiological Length	Maximum Diameter Proximal End	Nutrient Foramen A-P Diameter	Nutrient Foramen M-L Diameter	Fibula Length	Clavicle Length	Height	Breadth
BE 3	2B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B	L	-	-	-	22.3	29	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 135	2A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 136	1A	R	-	-	-	-	-	-	-	40	-	-	-	-	-	-	-	-	-	-
	1A	L	413.7*	-	-	23	31	-	-	39.3+	-	-	-	-	-	-	-	-	-	-
SR 138	1A	R	-	-	-	20.5	30.7	23+	23+	38+	-	-	-	-	29	18.5	-	-	-	-
	1A	L	-	-	-	20.6	30	23.2	22	39.5	-	-	-	-	29.5	17.2	-	-	-	-
CE 122	3A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI 149	3	R	-	-	-	22.6	32.6	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 139	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1A	L	-	-	-	26	33	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-1	4	R	-	-	-	24	30.7	-	-	39.4	-	-	-	-	-	-	-	-	-	-
	4	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-2	2	R	-	-	-	-	-	-	-	40.6	-	-	-	-	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-4	1	R	-	-	-	23	32	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Steele
+Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			HUMERUS						ULNA				RADIUS			PATELLA	
Tumuli	Burial	Side	Maximum Length	Maximum Head Diameter	Proximal end Breadth	Distal end Breadth	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Length	Shaft Length	Trochlear Notch Height	Distal End Breadth	Length	Maximum Head Diameter	Distal End Breadth	Maximum Height	Maximum Breadth
HE 150	1	R	-	-	-	-	-	-	-	-	19.7	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MALES																	
PO 300	2	R	280^{+}	-	-	-	18.8^{+}	19.6^{+}	237	-	15.9	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	31.7	36.3
PO 307	2	R	-	-	-	-	20.5	19.5	-	-	-	-	-	-	-	40.8	39.2
	2	L	321	43.5	23.2	48.5^{+}	20	20	-	-	-	-	-	20.5^{+}	30.5	39.5	41
DA 219	6	L	337^{*}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE 150	3	R	-	-	26	57.7	-	-	-	-	25.3	16.4	-	20.7	31.2	40.6	41.5
	3	L	315	44.3	26.7	58	22.5	20	-	-	25.2	-	232.6	-	31.4	40.2	43
	6	R	327	45.2	28.4	62.6	20	22.7	270	243	24	-	248	23.6	33	41	42.3
	6	L	-	-	-	-	-	-	268^{+}	245	-	17	252	21^{+}	34	-	-
	7	R	-	-	-	-	-	-	255^{+}	242	26.7	-	245^{+}	-	-	-	-
	7	L	317	42	26	60	21.5	24	-	-	-	16	-	-	-	-	-
CE 152	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	42	45
	1A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE 154	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	36.8	35.2
	1	L	312^{*}	-	-	50.7^{+}	-	-	-	-	22.3	-	-	-	-	-	-
DA 226	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Steele
\+ Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			FEMUR									TIBIA							SACRUM	
Tumuli	Burial	Side	Length	Bicondylar Length	Trochanteric Length	A-P Sub-trochanteric Diameter	M-L Sub-trochanteric Diameter	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Maximum Head Diameter	Epicondylar Breadth	Length	Physiological Length	Maximum Diameter Proximal End	Nutrient Foramen A-P Diameter	Nutrient Foramen M-L Diameter	Fibula Length	Clavicle Length	Height	Breadth
HE 150	1	R	423^*	-	-	27.3	30.6	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	31.4	20	-	-	-	-
										MALES										
PO 300	2	R	-	-	-	23^+	33	-	-	-	-	-	-	-	31.5	20	-	-	-	-
	2	L	-	-	-	26.5	33	-	-	-	-	-	-	-	32.8	20.4	-	-	-	-
PO 307	2	R	-	-	-	-	-	30^+	25^+	44.2	-	-	-	-	39	21.8	-	-	-	-
	2	L	451^+	-	-	27.5	24	29.5^+	23.5^+	44.6	-	-	-	-	36.7	22	317^+	-	-	-
DA 219	6	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE 150	3	R	422^+	420^+	394	30	27.5	31.4	23.2	46.5	73^+	362	357	68.7^+	38	26.7	-	140^+	114.5	115.7
	3	L	425	422	392	29.2	28	32.7	23.8	45.5	79	361	357	76.3	38.6	27.5	344	146^+	-	-
	6	R	-	-	-	-	-	-	-	-	-	381	380	73.5^+	26.6	39	365	-	-	-
	6	L	447	444	423	31	30.2	31	26.7	47^+	74.4^+	-	-	-	-	-	-	145	-	-
	7	R	440^+	-	-	-	-	28	25	-	-	-	-	-	36.4	24.2	-	-	-	112^+
	7	L	-	-	-	29.2	36.2	-	-	45	-	-	-	-	37.5	24.7	-	-	-	-
CE 152	1A	R	462^*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1A	L	472^*	-	-	-	-	-	-	-	-	-	-	-	35	21.5	-	-	-	-
CE 154	1	R	451^*	-	-	21.8	27	-	-	39.8^+	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 226	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	461^*	-	-	28.5	35.6	-	-	47.7	-	-	-	-	-	-	-	-	-	-

*Steele
+Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			HUMERUS						ULNA				RADIUS			PATELLA	
Tumuli	Burial	Side	Maximum Length	Maximum Head Diameter	Proximal end Breadth	Distal End Breadth	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Length	Shaft Length	Trochlear Notch Height	Distal End Breadth	Length	Maximum Head Diameter	Distal End Breadth	Maximum Height	Maximum Breadth
DA 226	3A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3A	L	343^*	-	-	62	-	-	-	-	29	-	-	21.7	-	-	-
	4A	R	329^*	-	-	59.2	-	-	-	-	23	-	-	-	-	-	-
	4A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4B	L	312^*	42.4^+	28	-	-	-	-	-	-	-	-	-	-	-	-
PO 306	4	R	-	-	-	-	-	-	-	-	23	-	228^+	22	-	46	-
	4	L	310^+	-	22.6	-	22	23	275^+	-	-	14.7^+	226^+	21.6	-	45.1	46.2
DA 246	2	R	329^*	-	-	-	-	-	-	-	21	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 117	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	335^*	-	-	-	-	-	-	-	23	-	-	-	-	-	-
BE 3	2A	R	-	49	-	-	-	-	-	-	-	-	-	-	-	-	-
	2A	L	342^*	49	-	-	-	-	-	-	24	-	-	22^+	-	-	-
BE 128	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	326^*	-	-	55.2	-	-	-	-	-	-	-	-	-	-	-
BE 136	1B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1B	l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SR 138	1B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1B	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Steele
\+ Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			FEMUR									TIBIA							SACRUM	
Tumuli	Burial	Side	Length	Bicondylar Length	Trochanteric Length	A-P Sub-trochanteric Diameter	M-L Sub-trochanteric Diameter	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Maximum Head Diameter	Epicondylar Breadth	Length	Physiological Length	Maximum Diameter Proximal End	Nutrient Foramen A-P Diameter	Nutrient Foramen M-L Diameter	Fibula Length	Clavicle Length	Height	Breadth
DA 226	3A	R	-	-	-	27	32	-	-	-	-	-	-	-	34	20.6	-	-	-	-
	3A	L	458*	-	-	27.6	31	-	-	46	-	-	-	-	-	-	-	-	-	-
	4A	R	458*	-	-	26	32.4	-	-	42+	-	-	-	-	-	-	-	-	-	-
	4A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4B	L	-	-	-	26	31	-	-	-	-	-	-	-	-	-	-	-	-	-
PO 306	4	R	-	-	-	-	-	-	-	45+	-	-	-	-	38	24	-	-	-	-
	4	L	-	-	-	-	-	-	-	-	-	-	-	-	39.2	25.6	-	-	-	-
DA 246	2	R	427*	-	-	25	31	-	-	-	-	370*	-	-	34	21.2	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 117	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 3	2A	R	-	-	-	25	30	-	-	-	-	-	-	-	-	-	-	-	-	-
	2A	L	-	-	-	25	33.6	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 128	1	R	456*	-	-	-	-	-	-	45.6+	-	-	-	-	26.5	39	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 136	1B	R	461.3*	-	-	28	34.7	-	-	-	-	-	-	-	-	-	-	-	-	-
	1B	1	-	-	-	-	-	-	-	-	-	-	-	-	40	28	-	-	-	-
SR 138	1B	R	-	-	-	-	-	-	-	-	-	-	-	-	37.7	23.5	-	-	-	-
	1B	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Steele
\+ Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			HUMERUS						ULNA				RADIUS			PATELLA	
Tumuli	Burial	Side	Maximum Length	Maximum Head Diameter	Proximal End Breadth	Distal End Breadth	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Length	Shaft Length	Trochlear Notch Height	Distal End Breadth	Length	Maximum Head Diameter	Distal End Breadth	Maximum Height	Maximum Breadth
CE 122	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2A	R	342*	-	-	-	-	-	-	-	-	-	-	23.4	-	-	-
	2A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2C	R	331*	-	-	-	-	-	-	-	-	16.7	-	-	-	-	-
	2C	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HI 149	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-1	2A	R	335*	-	-	59	-	-	-	-	24	-	-	21.5	-	-	-
	2A	L	-	-	-	-	-	-	-	-	-	17	-	21	-	-	-
BE 6-2	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1A	L	323	46.2	27.4	63.6	21.7	22.4	-	-	-	-	-	-	-	-	-
	1B	R	347.5+	50	26	65.4	-	-	-	-	-	-	-	-	-	-	-
	1B	L	-	-	-	63	-	-	-	-	-	-	-	-	-	-	-
BE 6-4	2	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 150	2	R	-	45.5	27	-	18.6	26.4	-	-	-	-	-	-	-	-	-
	2	L	340+	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Steele
\+ Approximate

APPENDIX IIIa

TABLE 41

Post-Cranial Measurements for Southwestern Missouri (in mm)

			FEMUR									TIBIA							SACRUM	
Tumuli	Burial	Side	Length	Bicondylar Length	Trochanteric Length	A-P Sub-trochanteric Diameter	M-L Sub-trochanteric Diameter	A-P Mid-shaft Diameter	M-L Mid-shaft Diameter	Maximum Head Diameter	Epicondylar Breadth	Length	Physiological Length	Maximum Diameter Proximal End	Nutrient Foramen A-P Diameter	Nutrient Foramen M-L Diameter	Fibula Length	Clavicle Length	Height	Breadth
CE 122	1	R	-	-	-	-	-	-	-	49+	-	382*	-	-	40.2	26	-	-	-	-
	1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2A	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2C	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2C	L	-	-	-	-	-	-	-	-	-	-	-	-	40	24.4	-	-	-	-
HI 149	1	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	L	-	-	-	25	32.5	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-1	2A	R	-	-	-	-	-	-	-	-	-	-	-	-	40	26	-	-	-	-
	2A	L	-	-	-	30.5	32.4	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-2	1A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1A	L	-	-	-	28.6	34	-	-	49.2+	-	-	-	77	35	25	-	-	-	-
	1B	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1B	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-4	2	R	-	-	-	26	36	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 150	2	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	L	-	-	-	34	23	-	-	-	-	-	-	-	-	-	-	-	-	-

*Steele
+Approximate

APPENDIX IIIa

TABLE 41

Cranial Measurements for Southwestern Missouri (in mm)

Tumuli	Burial	Maximum Length	Maximum Breadth	Minimum Frontal	Basion-Bregma ht.	Auricular Height	Facial Height		Nasal		Nasion Basion lt.	Basion-Prosthion lt.	Orbit		Foramen Magnum		Frontal Arc	Parietal arc	Occipital arc
							Total	Upper	Height	Breadth			Height	Breadth	Length	Breadth			
									FEMALES										
PO 300	1	-	140	-	-	102.3	-	-	-	-	-	-	-	-	-	-	-	135	117.5
PO 307	4A	173.5	-	90.5	-	108	-	-	-	-	-	-	-	-	-	-	118	124	-
DA 250	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 137	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 147	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	171	140	-	-	119.5	105.1+	-	46.5	20.6	-	-	-	-	-	-	120	126	-
CE 150	1A	-	-	-	-	-	-	-	-	21	-	-	-	-	41.4+	35.6	-	-	-
DA 225	1	184	-	93	-	117	-	-	-	-	-	-	38	43.6	-	-	125	126	-
DA 226	4C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE 148	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	117	-
PO 306	2	-	-	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5A	175	132	88	-	94	-	-	-	-	-	-	-	-	-	28	127	140	-
	6A	169	135	92.2+	134	110.5	105.5	65	45	27	97	98	37.7	47	38	32.5	115	133	114.5
	6B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 246	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 246	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 128	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 136	1A	-	139	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138	-
CE 122	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 139	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	116	-	-
DA 201	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 150	1	169	134.5	-	-	110	-	-	-	-	-	-	-	-	-	-	128	117	-

APPENDIX IIIa

TABLE 41

Cranial Measurements for Southwestern Missouri (in mm)

Tumuli	Burial	Bidacryonic Arc	Biporial Arc	Frontal Chord	Parietal Chord	Occipital Chord	Biasterionic Breadth	Ext. Palate Length	Ext. Palate Breadth	Int. Palate Height	Mandibular Length	Bicondylar Breadth	Bigonial Breadth	Ramus Height	Ramus Min. Breadth	Symphyseal Height	Inter-foraminal Breadth	Coronoid Height	Body Thickness (M2)
										FEMALES									
PO 300	1	-	309	-	116.6	103	103	-	-	-	-	-	-	-	-	-	-	-	-
PO 307	4A	-	-	104.3	112	-	-	-	-	-	96	-	78.2	49.4	31.6	32	40	54.5	12.2
DA 250	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 137	1	-	-	-	-	-	-	-	-	-	85	-	-	54	27.2	26	45.5	59.5	15.5
HE 147	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	42.6	-	14.6
	2	-	308[+]	108.7	110.5	-	108.7[+]	50	67.4	13.2	99.3	105[+]	93.5[+]	46.4	30	31	46.4	54.6	17
CE 150	1A	-	-	-	-	-	104	59.6	59.3	12.7	95	-	99	52.4	33	27.2[+]	45.5	-	15.6
DA 225	1	-	323	111	111.2	-	107	55.0	65.3	14.5	98	-	-	56.0	30.3	-	-	69	12.6
DA 226	4C	-	-	-	-	-	-	-	-	-	90	-	-	-	32	-	46.5	58.6	14
CE 148	1	-	-	-	98	-	98.2	-	-	-	-	-	-	45	26.7	-	-	55.4	14.3
PO 306	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5A	-	315	111	124	-	102	55	59.2	14	95	108	97	44.3	30.6	33.3	44.7	57.2	14
	6A	28[+]	303	104	116.2	92	105	58	66.2	10.6	95	-	-	55.6	35.5	26	45	59	16
	6B	-	-	-	-	-	99.6	-	-	-	-	-	-	43	28	-	-	-	14.3
DA 246	3	-	-	-	-	-	-	-	-	-	95[+]	-	98.4	44[+]	32.5	29.2	-	-	12.7
	4	-	-	-	-	-	-	-	-	-	96	-	-	52.1	-	27.2	42.7	-	14.5
BE 128	2	-	-	-	-	-	-	-	-	-	88	-	87	46	23.6	27.6	44.8	47.6	13
BE 136	1A	-	-	-	120	-	-	-	-	-	-	-	-	-	-	-	-	- -	-
CE 122	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	35	32.4	41.2	-	-
HE 139	2	-	-	106.5	-	-	-	-	-	-	-	-	-	60	-	-	-	-	17.3
DA 201	1	-	-	-	-	-	-	-	-	-	-	-	-	64	33.7	-	-	-	16
HE 150	1	30	291	108.8	106.2	-	103.4	-	54.6	13	-	-	-	-	-	-	-	-	-

[+]Approximate

APPENDIX IIIa

TABLE 41

Cranial Measurements for Southwestern Missouri (in mm)

							Facial Height		Nasal				Orbit		Foramen Magnum				
Tumuli	Burial	Maximum Length	Maximum Breadth	Minimum Frontal	Basion-Bregma ht.	Auricular Height	Total	Upper	Height	Breadth	Nasion-Basion lt.	Basion-Prosthion lt.	Height	Breadth	Length	Breadth	Frontal Arc	Parietal arc	Occipital arc
									MALES										
PO 300	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO 307	2	175	131	89	-	104	-	-	-	-	-	-	34	-	-	-	125	111	-
CE 150	3	186	136	95	-	120	-	72.1	59	30.5	-	-	38	49	-	-	131	134	126+
	6	196	-	104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	-	41	30+	-	-	-
CE 148	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PO 306	4	172	124	94+	-	104	-	-	-	-	-	-	-	-	-	-	110	138	-
DA 246	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129	-
BE 135	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	124	-
CE 122	2C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 139	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-1	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 6-2	1A	-	-	95.7	-	-	-	-	-	-	-	-	-	-	-	-	127	--	-
	1B	-	-	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	-	91	-	-	-	-	-	-	-	-	-	-	-	-	132	-	-
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	123.5	-
	6	-	-	83	-	-	-	-	-	-	-	-	-	-	-	-	117	-	-
CE 104	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HE 150	2	185+	143	-	174+	-	-	-	-	-	-	-	-	-	48.7	36	-	142	111
DA 226	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

+ Approximate

APPENDIX IIIa

TABLE 41

Cranial Measurements for Southwestern Missouri (in mm)

	Burial	Bidacryonic Arc	Biporial Arc	Frontal Chord	Parietal Chord	Occipital Chord	Biasterionic Breadth	Ext. Palate Length	Ext. Palate Breadth	Int. Palate Height	Mandibular Length	Bicondylar Breadth	Bigonial Breadth	Ramus Height	Ramus Min. Breadth	Symphyseal Height	Inter-foraminal Breadth	Coronoid Height	Body Thickness (M2)
										MALES									
PO 300	2	-	-	-	-	-	-	57	-	-	106	-	-	56.4	33.8	32.2	44	64.5	15
PO 307	2	-	303	110	95	-	105	-1	-	-	-	-	-	-	-	29.3	-	-	13
CE 150	3	28	324	112	112	101+	93	52	67	17.7	103+	131+	106	73.5	38	36	-	71	15
	6	-	-	118	120	-	106	57	67	16	102	122.6	106.5	59.5	38.6	37	46.7	70	13.6
	7	-	-	-	-	-	-	57	67	16.8	101	-	99	68	34.5	31	40.5	75	14.7
CE 148	2	-	-	-	-	-	102	-	-	-	-	-	-	-	-	-	-	-	16
PO 306	4	-	-	104.4	116	-	95	60	-	-	96	115.5+	104	58	33.7	31.7	45	68.2	13
DA 246	2	-	-	-	112	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BE 135	3	-	-	-	111.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CE 122	2C	-	-	-	-	-	-	-	-	-	-	-	-	-	37.3	-	-	-	14
HE 139	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44.6	-	-
BE 6-1	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38	-	-	13.8
BE 6-2	1A	-	-	114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1B	-	-	-	-	-	-	-	-	-	-	-	-	56.6	37	-	-	55	13.3
	4	-	-	116.4	-	-	-	57.2	62	13	-	-	-	-	-	-	-	-	14
	5	-	-	-	105.6	-	-	50.6	61.4	-	-	-	-	-	30	34	42.5	48.5+	10.7
	6	-	-	106.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.7
CE 104	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34.2	-	-	13.8
HE 150	2	-	-	-	124.7	97	118+	-	-	-	102	-	101.4	60.7	37	36.5	47.3	-	18.1
DA 226	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.6	46	-	13
	4B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38	-	-	16.2

+Approximate

APPENDIX IIIb

TABLE 42

Scoring Procedure and Non-Metric Variants

GENERAL

1. Absent
2. Present
9. Unknown

MYLOHYOID ARCH

1. Absent
2. Partial arch
3. Complete arch
4. Enters from mandibular canal, no further arch
5. Enters from mandibular canal and includes the arch

DIVIDED HYPOGLOSSAL CANAL

1. Absent
2. Partial on medial surface of canal (near foramen magnum)
3. Complete of above
4. Partial internal division
5. Complete internal division

MULTIPLE ZYGOMATICO-FACIAL FORAMINA

1. Absent
2. Single
3. Present

POSTERIOR BRIDGING ON ATLAS

1. Absent
2. Partial
3. Complete

APPENDIX IIIb

TABLE 42

Scoring Procedure and Non-Metric Variants

Tumulus	Burial	Asterionic Bone	Parietal Notch Bone	Supra-Orbital Foramina	Multiple Mental Foramina	Mylohyoid Arch	Divided Hypoglossal Canal	Multiple Zygomatico-Facial Foramina	Pterygo-Alar Spur	Ossicle at Lambda	Superior Sagittal Sulcus Flexes Rt.	Posterior Bridging on Atlas
BE3	2a	9	9	1	9	9	9	9	9	9	9	9
	2b	9	9	1	9	9	9	9	9	9	9	9
	A	9	9	2	9	9	9	9	9	9	9	9
BE128	2	9	9	9	2	1	9	9	9	9	9	9
	?	9	9	2	9	9	9	9	9	9	9	9
BE6-1	2a	9	9	9	1	1	9	1	9	9	9	9
BE6-2	1a	9	9	2	1	9	9	9	9	9	9	9
	1b	9	9	2	2	3	9	9	9	9	9	9
	4	1	1	2	9	9	9	9	9	9	9	9
	5	1	9	9	9	9	9	9	9	1	9	9
	6	1	1	1	9	9	9	9	9	9	9	9
BE6-3	1	9	9	2	9	9	9	9	9	9	9	9
BE135	1	9	9	9	9	9	9	9	9	2	9	9
	2a	9	9	9	1	9	9	9	9	9	9	9
BE136	1a	1	1	2	9	9	9	9	9	2	9	9
SR138	1	9	9	9	9	9	1	9	9	9	9	9
CE122	2b	9	9	9	1	1	9	9	9	9	9	9
	2c	9	9	9	9	1	9	9	9	9	9	9
	3a	9	9	2	9	9	9	9	9	9	9	9
	C	9	9	2	9	9	9	9	9	9	9	9
HE139	1b	9	9	9	1	9	9	9	9	9	9	9
	2	9	9	2	2	1	9	9	9	9	9	9
	3	9	9	2	9	9	9	9	9	9	9	9

APPENDIX IIIb

TABLE 42

Scoring Procedure and Non-Metric Values

Tumulus	Burial	Asterionic Bone	Parietal Notch Bone	Supra-Orbital Foramina	Multiple Mental Foramina	Mylohyoid Arch	Divided Hypoglossal Canal	Multiple Zygomatico-Facial Foramina	Pterygo-Alar Spur	Ossicle at Lambda	Superior Sagittal Sulcus Flexes Rt.	Posterior Bridging on Atlas
DA201	1	9	9	2	2	1	9	9	9	9	9	9
HE150	1	1	1	2	9	9	5	2	9	1	9	9
	2	2	1	9	1	1	1	2	9	2	9	9
HI135	1	9	9	9	1	9	9	9	9	9	9	9
HE147	1	9	9	9	1	1	9	9	9	9	9	9
	2	1	1	2	1	1	9	2	4	1	9	9
CE150	1a	1	9	2	1	3	1	9	9	1	9	9
	3	1	2	2	1	3	9	9	9	1	9	9
	4	1	9	9	9	9	9	9	9	1	9	9
	6	9	9	1	1	1	1	2	9	1	9	1
	7	1	1	1	2	1	1	9	9	1	9	9
	10	9	9	9	1	9	9	9	9	9	9	9
CE148	1	1	9	2	1	3	9	9	9	1	9	9
	2	1	9	2	9	1	9	9	9	1	9	9
	6a	9	9	2	9	9	9	9	9	9	9	9
	6b	9	9	1	9	9	9	9	9	9	9	9
DA246	2	1	9	9	9	9	1	2	9	1	9	9
	3	9	9	9	1	1	9	9	9	9	9	9
	4	9	9	9	1	3	9	9	9	9	9	9
DA225	1	1	1	1	1	1	5	2	9	1	9	9
BE137	1	9	9	9	1	9	9	1	9	9	9	9
	2a	1	9	1	9	9	9	9	9	1	9	9

APPENDIX IIIb

TABLE 42

Scoring Procedure and Non-Metric Variants

Tumulus	Burial	Asterionic Bone	Parietal Notch Bone	Supra-Orbital Foramina	Multiple Mental Foramina	Mylohyoid Arch	Divided Hypoglossal Canal	Multiple Zygomatico-Facial Foramina	Pterygo-Alar Spur	Ossicle at Lambda	Superior Sagittal Sulcus Flexes Rt.	Posterior Bridging on Atlas
P0307	2	1	1	1	1	3	9	9	9	1	9	9
	4a	2	9	2	1	3	9	2	9	1	9	9
	6	9	9	9	1	3	9	9	9	9	9	9
P0300	1	1	1	9	9	9	1	9	9	1	9	9
	2	1	9	9	1	1	9	9	9	1	9	9
P0306	2	9	9	1	9	9	9	9	9	1	9	9
	4	1	1	2	1	1	1	2	9	1	9	9
	5a	2	1	1	1	1	1	2	9	2	9	1
	6a	1	1	1	1	1	5	2	9	2	9	9
	6b	1	1	9	1	1	9	9	9	1	9	9

APPENDIX IV

TABLE 43

Tumulus Descriptions of Burial Types

Tumulus	Articulated		Reburial[1]		Bundle Secondary		Ossuary		True Broadcast		Concentrated BC	Perimeter Burial	Isolated Elements		Primary Remains	
	Extend	Flexed/ Semi-flexed	UB	B	UB	B	UB	B	Cremation	Unburned			UB	B	UB	B
HI 135	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
PO 305	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
CE 148	-	+	+	-	+	-	-	-	+	-	-	-	-	-	+	-
CE 150	+	+	-	-	+	-	-	-	+	-	+	-	+	-	+	+
CE 152	-	-	-	+	+	-	-	-	+	+	-	-	-	-	-	-
CE 154	-	+	-	-	-	-	-	-	+	-	-	+	-	-	-	-
DA 222	-	-	-	-	+	-	-	-	+	+	-	-	-	-	+	+
DA 225	-	+	-	-	+	-	-	-	+	+	-	-	-	-	+	+
DA 226	-	+	-	-	+	-	+	-	+	+	-	+	-	-	+	-
DA 246	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	+
PO 306	+	+	-	-	+	+	-	-	+	-	+	-	+	-	+	-
BE 6-1	-	-	-	-	+	-	-	-	+	?	+	-	-	-	+	-
BE 6-2	-	-	-	-	+	+	+	+	+	-	-	-	-	-	+	-
BE 6-3	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	+
BE 6-4	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-
BE 3	-	-	-	-	+	-	+	+	+	-	-	-	-	-	+	+
BE 128	-	-	-	-	+	+	+	+	+	-	-	-	-	-	+	-
BE 117	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-
BE 118	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-
BE 135	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+	+
BE 136	-	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-
CE 104	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-
CE 122	-	-	-	-	+	-	+	-	+	-	-	-	-	-	+	+

APPENDIX IV

TABLE 43: Continued

Tumulus Descriptions of Burial Types

Tumulus	Articulated		Reburial[1]		Bundle Secondary		Ossuary		True Broadcast		Concentrated BC	Perimeter Burial	Isolated Elements		Primary Remains	
	Extend	Flexed/ Semi-flexed	UB	B	UB	B	UB	B	Cremation	Unburned			UB	B	UB	B
CE 190	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-
CE 198	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-
DA 201	-	-	-	-	+	-	-	-	+	+	-	-	-	-	+	-
HE 139	+	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-
HI 30c	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-
HI 149	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
SR 111	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
SR 138	-	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-
SR 141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
HE 150	?	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+
CE 123	-	+	+	-	+	+	-	-	+	+	-	-	-	-	-	-
PO 300	-	+	-	-	+	+	+	+	+	-	-	-	-	-	-	-
PO 301	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
PO 307	+	+	-	+	+	-	-	-	+	-	-	-	-	-	+	-
HI 18	-	-	-	-	?	-	-	-	-	+?	-	-	-	-	-	-
HI 30	-	-	-	-	-	-	-	-	+	?	-	-	-	-	+	-
PO 304	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
DA 250	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 216	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
DA 237	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
DA 219	-	-	-	-	+	-	+	-	+	+	-	-	-	-	+	-
BE 137	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-

APPENDIX IV

TABLE 43: Continued

Tumulus Descriptions of Burial Types

Tumulus	Articulated		Reburial[1]		Bundle Secondary		Ossuary		True Broadcast		Concentrated BC	Perimeter Burial	Isolated Elements		Primary Remains	
	Extend	Flexed/ Semi-flexed	UB	B	UB	B	UB	B	Cremation	Unburned			UB	B	UB	B
HE 147	-	+	-	-	+	+	-	-	+	-	-	-	-	-	-	-
PO 165	-	-	-	-	?	?	-	-	+	-	-	-	-	-	-	-
DA 221	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

-(minus) = No

+(plus) = Yes

? = Uncertain

[1]Burials intentionally arranged approximating anatomical position; UB = unburned and B = burned throughout the table.

APPENDIX V

TABLE 44

Tumulus Descriptions of Tumuli Features

Tumulus	Masonry Chamber	Shape	CONTENT: Individual Burial(s) UB	Individual Burial(s) B	Broadcast Burial(s) UB	Broadcast Burial(s) B	Slabbed Floor	Pit Burial w/n chamber UB	Pit Burial w/n chamber B	Bone Confined to Chamber	Individual Burial Pit(s)	Shape	CONTENT: Clay Packed[2]	Slabbed Pit UB	Slabbed Pit B	Individual Burial(s) UB	Individual Burial(s) B	Cremation	Rock Filled UB	Rock Filled B	Bone in Fill UB	Bone in Fill B	Stone Capped	Burials Overlying
HI 135	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
PO 305	-	..	..	..	..	..	..	..	..	..	+	Rect.	-	-	+	-	+	+	-	+	+	+	-	-
CE 148	+	Oval	+	-	-	+	+	+	-	-	+	Oval	?	-	-	+	-	-	-	-	-	-	-	+
CE 150	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
CE 152	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
CE 154	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 222	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 225	+	Oval	+	-	+	+	-	+	-	?	+	Oval	?	-	-	+	-	-	-	-	-	+	+	-
DA 226	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 246	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
PO 306	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 6-1	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 6-2	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 6-3	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 6-4	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 3	+	Oval	+	-	-	-	-	-	-	-	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 128	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 117	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 118	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 135	-	-	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 136	+	Oval	+	-	+	+	-	-	+	+(?)	+	Oval	-	-	-	-	+	+	-	-	-	+	-	+

APPENDIX V

TABLE 44

Tumulus Descriptions of Tumuli Features

Tumulus	Features[3]	Shape	Human Bone UB	Human Bone B	Animal Bone UB	Animal Bone B	Artifacts	Debris	Rock Filled	Provenience	Burials Overlying	Tumulus Preparation for Burial[4]	Distribution: Bone	Distribution: Artifacts	Burned Artifacts	Burned Rock: Fill	Burned Rock: Tumulus Base	Super-Imposition of Burials	Dog Burials
HI 135	None	..	..	..	..	..	..	..	..	..	..	-	Cntr & SW	Ctr & SW	-	?	?	-	-
PO 305	None	..	..	..	..	..	..	..	..	..	..	+	Cntr pit	?	-	-	-	-	-
CE 148	None	..	..	..	..	..	..	..	..	..	..	+	Cntr & SW	Cntr & SW	+	+	-	+	-
CE 150	None	..	..	..	..	..	..	..	..	..	..	-	N½	Cntr & E½	+	+	?	+	-
CE 152	None	..	..	..	..	..	..	..	...	..	..	-	Cntr	Conc. in cntr;Entire	+	+	-	-	+
CE 154	1	Round	-	-	-	-	+	-	+	NW	+	+	NW	Conc. in W; Entire	+	+	?	-	-
DA 222	None	..	..	..	..	..	..	...	..	..	..	-	SW	SW	+	+	-	-	-
DA 225	None	..	..	..	..	..	..	..	..	..	..	+	N ½	Entire chamber	+	+	?	-	-
DA 226	None	..	..	..	..	..	..	..	..	..	..	-	Cntr & E½	Cntr & E½	+	-	-	-	+
DA 246	None	..	..	..	..	..	..	..	..	..	..	-	NW & SE	Entire except SW	+	+	?	-	-
PO 306	None	..	..	..	..	..	..	..	..	..	..	+	Cntr	Cntr	+	+	-	-	-
BE 6-1	None	..	..	..	..	..	..	..	..	..	..	-	Cntr & E	Entire	+	+	-	-	-
BE 6-2	None	..	..	..	..	..	..	..	..	..	..	-	Cntr	Cntr & SE	+	+	?	-	-
BE 6-3	None	..	..	..	..	..	..	..	..	..	..	+	E½	E½	-	-	?	-	-
BE 6-4	None	..	..	..	..	..	..	..	..	..	..	-	E½	Entire	-	-	-	-	-
BE 3	None	..	..	..	..	..	..	..	..	..	..	+	Cntr	Entire	+	+	?	-	-

APPENDIX V

TABLE 44: Continued

Tumulus Descriptions of Tumuli Features

Tumulus	Masonry Chamber	Shape	CONTENT: Individual Burial(s)		CONTENT: Broadcast Burial(s)		Slabbed Floor	Pit Burial w/n Chamber		Bone Confined to Chamber	Individual Burial Pit(s)	Shape	Clay Packed[2]	CONTENT: Slabbed Pit		CONTENT: Individual Burial(s)		Cremation	Rock Filled		Bone in Fill		Stone Capped	Burials Overlying
			UB	B	UB	B		UB	B					UB	B	UB	B		UB	B	UB	B		
CE 104	-	..	..	..	..	..	..	..	..	..	+	Irreg. Circle	+	-	-	-	-	+	-	-	-	-	-	+
CE 122	+	Oval	+	-	-	+	-	-	-	+	-	..	..	..	..	..	..	..	..	..	..	..	..	..
CE 190	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
CE 198	+	Circle	-	-	+	+	-	-	-	+	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 201	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
HE 139	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
HI 30c	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
HI 149	-	..	..	..	..	..	..	..	..	..	+	Oval	-	-	-	+	?	-	-	-	?	?	-	-
SR 111	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
SR 138	-	..	..	..	...	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
SR 141	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
HE 150	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
CE 123	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
PO 300	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
PO 301	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
PO 307	-	..	..	..	..	..	..	..	..	..	+	Rect.	-	-	-	+	+	-	-	-	?	?	-	-
HI 18	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
HI 30	+	Square	+	-	?	+	-	-	-	+	-	..	..	..	...	..	..	..	..	..	..	..	..	..
	+	Oval (inside square)	?	?	?	?	-	-	-	-	-	..	..	..	..	..	..	..	..	..	..	..	..	..

APPENDIX V

TABLE 44: Continued

Tumulus Descriptions of Tumuli Features

Tumulus	Features[3]	Shape	Human Bone UB	Human Bone B	Animal Bone UB	Animal Bone B	Artifacts	Debris	Rock Filled	Provenience	Burials Overlying	Tumulus Preparation for Burials[4]	Distribution: Bone	Distribution: Artifacts	Burned Artifacts	Burned Rock: Fill	Burned Rock: Tumulus Base	Superimposition of Burials	Dog Burials
BE 128	None	..	..	..	..	..	..	..	..	..	..	-	Cntr	Entire	+	+	?	-	-
BE 117	None	..	..	..	..	..	..	..	..	..	..	+	S Cntr	Entire	+	?	?	-	-
BE 118	None	..	..	..	..	..	..	..	..	..	..	-	S	C & S	+	?	?	-	-
BE 135	None	..	..	..	..	..	..	..	..	..	..	+(?)	SE¼	E½	-	+	?	+	-
BE 136	None	..	..	..	..	..	..	..	..	..	..	+	C of N½	Entire except SE¼	+ +	+ +	-	+	+(?)
CE 104	2	Heart	-	-	-	-	-	+	-	SE	-	+	Cntr	Cntr	+	?	+	-	-
CE 122	None	..	..	..	..	..	..	..	..	..	-	+	Entire Chamber	Entire Chamber	-	+	-	-	-
CE 190	None	..	..	..	..	..	..	..	..	..	..	+	E½	NE¼	-	+	?	-	-
CE 198	None	...	..	..	..	..	..	..	..	..	..	+	W½ of Chamber	E½ of Chamber	+	-	-	-	-
DA 201	None	..	..	..	..	..	..	..	..	..	..	-	E½	E½	-	+	?	-	-
HE 139	None	..	..	..	..	..	..	..	..	..	..	-	Entire	Entire	-	-	?	-	?
HI 30c	None	..	..	..	..	..	..	..	..	..	..	-	Cntr	E½	-	-	?	-	-
HI 149	None	..	..	..	..	..	..	..	..	..	..	+	Cntr	E½	-	-	?	-	-
SR 111	None	..	..	..	..	..	..	..	..	..	..	?	?	?	+	-	?	-(?)	-(?)
SR 138	None	..	..	..	..	..	..	..	..	..	..	-	NE	Entire	+	+	?	-	-
SR 141	None	..	..	..	..	..	..	..	..	..	..	-	Cntr	SW	+	-	-	-	-
HE 150	None	..	..	..	..	..	..	..	..	..	..	-	N½	N½	?	?	?	-	-
CE 123	None	..	..	..	..	..	..	..	..	..	..	-	Cntr	Entire	+	?	-	-	-

APPENDIX V

TABLE 44: Continued

Tumulus Descriptions of Tumuli Features

Tumulus	Masonry Chamber	Shape	CONTENT: Individual Burial(s) UB	Individual Burial(s) B	Broadcast Burial(s) UB	Broadcast Burial(s) B	Slabbed Floor	Pit Burial w/n Chamber UB	Pit Burial w/n Chamber B	Bone confined to Chamber	Individual Burial Pit(s)	Shape	Clay Packed[2]	CONTENT: Slabbed Pit UB	Slabbed Pit B	Individual Burial(s) UB	Individual Burial(s) B	Cremation	Rock Filled UB	Rock Filled B	Bone in Fill UB	Bone in Fill B	Stone Capped	Burials Overlying
PO 304	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 250	+	Oval	+	-	-	-	-	-	-	-	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 216	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 237	-	..	..	..	..	..	..	..	..	..	+	?	-	-	-	-	-	+	-	-	?	?	-	-
DA 219	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
BE 137	-	..	..	..	..	..	..	..	..	..	+	Oval	+	-	-	-	+	-	-	-	-	-	+	+
HE 147	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
PO 165	-	..	..	..	..	..	..	..	..	..	-	..	..	..	..	..	..	..	..	..	..	..	..	..
DA 221	-	..	..	..	..	..	..	..	..	..	+	Rect.	-	-	-	+	-	-	-	-	-	-	-	-

- (minus) = No
+ (plus) = Yes
.. = Not applicable
? = Uncertain

[1] Includes those found within a masonry chamber.

[2] Indicates intentional strengthening of walls or floor.

[3] Features included are only those not intended as burial pits.

[4] Includes all manner of tumuli alteration from clearing of the bedrock to masonry chambers.

APPENDIX V

TABLE 44: Continued

Tumulus Descriptions of Tumuli Features

Tumulus	Feature[3]	Shape	CONTENT: Human Bone UB	Human Bone B	Animal Bone UB	Animal Bone B	Artifacts	Debris	Rock Filled	Provenience	Burials Overlying	Tumulus Preparation for Burials[4]	DISTRIBUTION: Bone	DISTRIBUTION: Artifacts	Burned Artifacts	BURNED ROCK: Fill	BURNED ROCK: Tumulus Base	Superimposition of Burials	Dog Burials
PO 300	None	..	..	..	..	..	..	..	..	..	..	+	NE	E to SE½	+	+	?	+	-
PO 301	None	..	..	..	..	..	..	..	..	..	..	?	E½	N½	+	+	-	-	-
PO 307	1	Oval	-	-	-	-	+	+	-	C	+(?)	+	Cntr	Cntr	+	+	-	-	-
HI 18	None	..	..	..	..	..	..	..	..	..	..	?	Cntr to SE	N½	-	-	?	?	-
HT 30	None	..	..	..	..	..	..	..	..	..	..	+	?	?	?	?	?	?	?
	None	..	..	..	..	..	..	..	..	..	..	+	w/n entire chamber	w/n entire chamber	-	-	?	-	-
PO 304	None	..	..	..	..	..	..	..	..	..	..	-	entire except SE	Entire	-	-	-	-	-
DA 250	None	..	..	..	..	..	..	..	..	..	..	+	Cntr	Entire	-	-	-	-	-
DA 216	1	Circle	-	-	-	-	-	+	-	EC	-	+	Cntr	Entire	?	-	-	-	-
	2	Triang.	-	+	-	-	+	+	-	NC	-	..	..	...	..	..	..	..	..
	3	Circle	-	-	-	-	-	+	-	SE	-	..	..	..	..	..	..	..	..
DA 237	None	..	..	..	..	..	..	..	..	..	..	+	Cntr	S½	-	-	?	-	-
DA 219	1	Irreg	-	-	-	-	-	+	-	EC	-	+	N½	Entire except NW	+	+	+	-	-
BE 137	None	..	..	..	..	..	..	..	..	..	..	+	Cntr	None	-	+	?	+	-
HE 147	None	..	..	..	..	..	..	..	..	..	..	-	Entire exc. SE	None	-	-	-	-	-
PO 165	None	..	..	..	..	..	..	..	..	..	..	-	?	?	-	-	?	?	-
DA 221	None	..	..	..	..	..	..	..	..	..	..	+	Cntr	Entire	-	-	-	-	-

APPENDIX VI

RESULTS OF THE CROSS-TABULATION OF INDIVIDUAL BODIES

APPENDIX VI

TABLE 45

Crosstabulation By Sex and Burial

SEX	COUNT / ROW PCT / COL PCT / TOT PCT	ART 1.	REART 2.	BUND 3.	PR 4.	BC 5.	CONCBE 6.	ROW TOTAL
FEMALE	1.	10	3	16	14	7	1	51
		19.6	5.9	31.4	27.5	13.7	2.0	47.2
		62.5	60.0	43.2	45.2	46.7	25.0	
		9.3	2.8	14.8	13.0	6.5	0.9	
MALE	2.	6	2	21	17	8	3	57
		10.5	3.5	36.8	29.8	14.0	5.3	52.8
		37.5	40.0	56.8	54.8	53.3	75.0	
		5.6	1.9	19.4	15.7	7.4	2.8	
	COLUMN TOTAL	16	5	37	31	15	4	108
		14.8	4.6	34.3	28.7	13.9	3.7	100.0

CHI SQUARE = 2.90830 WITH 5 DEGREES OF FREEDOM SIGNIFICANCE = 0.7141

NUMBER OF MISSING OBSERVATIONS = 194

Legend:

Art - articulated
Reart - rearticulated
Bund - bundle burial
Pr - primary remains
Bc - broadcast burial
Concbe - concentrated broadcast burial

APPENDIX VI

TABLE 46

Crosstabulation of Sex by Burn

SEX	COUNT / ROW PCT / COL PCT / TOT PCT	BURN: UB 1.	B 2.	ROW TOTAL
FEMALE	1.	40	11	51
		78.4	21.6	47.2
		50.6	37.9	
		37.0	10.2	
MALE	2.	39	18	57
		68.4	31.6	52.8
		49.4	62.1	
		36.1	16.7	
	COLUMN TOTAL	79	29	108
		73.1	26.9	100.0

CORRECTED CHI SQUARE = 0.91086 WITH 1 DEGREE OF FREEDOM. SIGNIFICANCE = 0.3399
RAW CHI SQUARE = 1.37322 WITH 1 DEGREE OF FREEDOM. SIGNIFICANCE = 0.2413

NUMBER OF MISSING OBSERVATIONS = 194

Legend:

UB - unburned
B - burned

APPENDIX VI

TABLE 47

Crosstabulation By Sex and Where

SEX	COUNT / ROW PCT / COL PCT / TOT PCT	NCOSURF 1.	NCMDFILL 2.	NCCREV 3.	NCSUPER 4.	NCPIT 6.	CFSURF 7.	CFFILL 8.	CFSUPER 9.	CFCHAMB 10.	CFPIT 11.	ROW TOTAL
FEMALE 1.	COUNT	22	7	3	1	1	3	0	2	3	3	49
	ROW PCT	44.9	14.3	6.1	2.0	2.0	6.1	0.0	4.1	6.1	6.1	47.1
	COL PCT	45.8	46.7	50.0	33.3	50.0	50.0	0.0	66.7	30.0	75.0	
	TOT PCT	21.2	6.7	2.9	1.0	1.0	2.9	0.0	1.9	2.9	2.9	
MALE 2.	COUNT	26	8	3	2	1	3	2	1	7	1	55
	ROW PCT	47.3	14.5	5.5	3.6	1.8	5.5	3.6	1.8	12.7	1.8	52.9
	COL PCT	54.2	53.3	50.0	66.7	50.0	50.0	100.0	33.3	70.0	25.0	
	TOT PCT	25.0	7.7	2.9	1.9	1.0	2.9	1.9	1.0	6.7	1.0	
COLUMN TOTAL		48	15	6	3	2	6	2	3	10	4	104
		46.2	14.4	5.8	2.9	1.9	5.8	1.9	2.9	9.6	3.8	100.0

SEX	COUNT / ROW PCT / COL PCT / TOT PCT	CFPITCHA 12.	ROW TOTAL
FEMALE 1.	COUNT	4	49
	ROW PCT	8.2	47.1
	COL PCT	80.0	
	TOT PCT	3.8	
MALE 2.	COUNT	1	55
	ROW PCT	1.8	52.9
	COL PCT	20.0	
	TOT PCT	1.0	
COLUMN TOTAL		5	104
		4.8	100.0

CHI SQUARE = 7.14429 WITH 10 DEGREES OF FREEDOM SIGNIFICANCE = 0.7118

NUMBER OF MISSING OBSERVATIONS = 198

Legend:

NCOSURF-non-central original ground surface
NCMDFILL-non-central mound fill
NCCREV-non-central crevice
NCSUPER-non-central superimposed
NCPIT-non-central burial pit
CFSURF-central feature, original ground surface
CFFILL-central feature, mound fill
CFSUPER-central feature, superimposed
CFCHAMB-central feature, chamber
CFPIT-central feature, burial pit
CFPITCHA-central feature, burial pit within a chamber

APPENDIX VI

TABLE 48

Crosstabulation By Sex and Whom

SEX (COUNT / ROW PCT / COL PCT / TOT PCT)	WHOM: WF 1.	WM 2.	W C 3.	WFC 4.	WMC 5.	TWOMC 7.	FMC 8.	TWOC 10.	FCS 11.	MCS 12.	ROW TOTAL
FEMALE 1.	4 14.8 40.0 7.8	6 22.2 100.0 11.8	3 11.1 50.0 5.9	2 7.4 28.6 3.9	5 18.5 71.4 9.8	2 7.4 100.0 3.9	0 0.0 0.0 0.0	1 3.7 100.0 2.0	0 0.0 0.0 0.0	4 14.8 100.0 7.8	27 52.9
MALE 2.	6 25.0 60.0 11.8	0 0.0 0.0 0.0	3 12.5 50.0 5.9	5 20.8 71.4 9.8	2 8.3 28.6 3.9	0 0.0 0.0 0.0	2 8.3 100.0 3.9	0 0.0 0.0 0.0	4 16.7 100.0 7.8	0 0.0 0.0 0.0	24 47.1
COLUMN TOTAL	10 19.6	6 11.8	6 11.8	7 13.7	7 13.7	2 3.9	2 3.9	1 2.0	4 7.8	4 7.8	51 100.0

SEX (COUNT / ROW PCT / COL PCT / TOT PCT)	WHOM: FMCS 13.	ROW TOTAL
FEMALE 1.	0 0.0 0.0 0.0	27 52.9
MALE 2.	2 8.3 100.0 3.9	24 47.1
COLUMN TOTAL	2 3.9	51 100.0

CHI SQUARE = 23.87750 WITH 10 DEGREES OF FREEDOM SIGNIFICANCE = 0.0079

NUMBER OF MISSING OBSERVATIONS = 251

Legend:

WF- with a female
WM- with a male
WC- with a child
WFC- with a female and child
WMC- with a male and child
TWOMC- Two males and a child
FMC- Other females or males and a child
TWOC- Two children
FCS- Females and children
MCS- Males and children
FMCS- Other females, males, and children

APPENDIX VI

TABLE 49

Crosstabulation of Sex by Ossuary

```
                    VAR015
            COUNT  I
          ROW PCT  I                          ROW
          COL PCT  I                          TOTAL
          TOT PCT  I       0.I       1.I
SEX        --------I---------I---------I
              1.   I    44   I     7   I     51
  FEMALE           I  86.3   I  13.7   I   47.2
                   I  48.9   I  38.9   I
                   I  40.7   I   6.5   I
                  -I---------I---------I
              2.   I    46   I    11   I     57
  MALE             I  30.7   I  19.3   I   52.8
                   I  51.1   I  61.1   I
                   I  42.6   I  10.2   I
                  -I---------I---------I
           COLUMN       90        18        108
            TOTAL     83.3      16.7      100.0

CORRECTED CHI SQUARE =     0.26749 WITH 1 DEGREE OF FREEDOM.   SIGNIFICANCE =  0.6050
      RAW CHI SQUARE =     0.60186 WITH 1 DEGREE OF FREEDOM.   SIGNIFICANCE =  0.4379

NUMBER OF MISSING OBSERVATIONS =      194
```

Legend:

Var 015 = presence (1) or absence (0) in an ossuary

APPENDIX VI

TABLE 50

Crosstabulation of Age by Burial

AGE	COUNT / ROW PCT / COL PCT / TOT PCT	IART 1.	REART 2.	BUND 3.	PR 4.	BC 5.	CONCBE 6.	ROW TOTAL
SUBADULT	0.	11	1	45	17	33	2	109
		10.1	0.9	41.3	15.6	30.3	1.8	36.1
		39.3	16.7	45.9	34.0	28.7	40.0	
		3.6	0.3	14.9	5.6	10.9	0.7	
ADULT	1.	17	5	53	33	82	3	193
		8.8	2.6	27.5	17.1	42.5	1.6	63.9
		60.7	83.3	54.1	66.0	71.3	60.0	
		5.6	1.7	17.5	10.9	27.2	1.0	
	COLUMN TOTAL	28	6	98	50	115	5	302
		9.3	2.0	32.5	16.6	38.1	1.7	100.0

CHI SQUARE = 8.06328 WITH 5 DEGREES OF FREEDOM SIGNIFICANCE = 0.1528

APPENDIX VI

TABLE 51

Crosstabulation of Age By Burn

```
                 BURN
           COUNT  I
         ROW PCT IUB        B          ROW
         COL PCT I                     TOTAL
         TOT PCT I      1.I       2.I
AGE      --------I--------I--------I
              0. I    77  I    21  I    98
  SUBADULT       I  78.6  I  21.4  I  33.8
                 I  44.5  I  17.9  I
                 I  26.6  I   7.2  I
                -I--------I--------I
              1. I    96  I    96  I   192
  ADULT          I  50.0  I  50.0  I  66.2
                 I  55.5  I  82.1  I
                 I  33.1  I  33.1  I
                -I--------I--------I
          COLUMN     173       117      290
           TOTAL    59.7      40.3    100.0

CORRECTED CHI SQUARE =    20.83569 WITH 1 DEGREE OF FREEDOM.  SIGNIFICANCE =  0.0000
      RAW CHI SQUARE =    22.00677 WITH 1 DEGREE OF FREEDOM.  SIGNIFICANCE =  0.0000

NUMBER OF MISSING OBSERVATIONS =       12
```

APPENDIX VI

TABLE 52

Crosstabulation of Age By Where

AGE (COUNT / ROW PCT / COL PCT / TOT PCT)		INCOSURF 1.	NCMDFILL 2.	NCCREV 3.	NCSUPER 4.	NCCHAMB 5.	NCPIT 6.	CFSURF 7.	CFFILL 8.	CFSUPER 9.	CFCHAMB 10.	ROW TOTAL
SUBADULT	0.	38	29	4	1	0	0	3	2	1	12	98
		38.8	29.6	4.1	1.0	0.0	0.0	3.1	2.0	1.0	12.2	35.5
		40.9	31.5	36.4	33.3	0.0	0.0	27.3	28.6	25.0	38.7	
		13.8	10.5	1.4	0.4	0.0	0.0	1.1	0.7	0.4	4.3	
ADULT	1.	55	63	7	2	2	2	8	5	3	19	178
		30.9	35.4	3.9	1.1	1.1	1.1	4.5	2.8	1.7	10.7	64.5
		59.1	68.5	63.6	66.7	100.0	100.0	72.7	71.4	75.0	61.3	
		19.9	22.8	2.5	0.7	0.7	0.7	2.9	1.8	1.1	6.9	
COLUMN TOTAL		93	92	11	3	2	2	11	7	4	31	276
		33.7	33.3	4.0	1.1	0.7	0.7	4.0	2.5	1.4	11.2	100.0

AGE (COUNT / ROW PCT / COL PCT / TOT PCT)		CFPIT 11.	CFPITCHA 12.	CRSUPCHA 13.	ROW TOTAL
SUBADULT	0.	2	4	2	98
		2.0	4.1	2.0	35.5
		25.0	44.4	66.7	
		0.7	1.4	0.7	
ADULT	1.	6	5	1	178
		3.4	2.8	0.6	64.5
		75.0	55.6	33.3	
		2.2	1.8	0.4	
COLUMN TOTAL		8	9	3	276
		2.9	3.3	1.1	100.0

Legend:

CRSUPCHA = central feature, superimposed in a chamber

CHI SQUARE = 6.78983 WITH 12 DEGREES OF FREEDOM SIGNIFICANCE = 0.8712

NUMBER OF MISSING OBSERVATIONS = 26

APPENDIX VI

TABLE 53

Crosstabulation By Age By Whom

AGE	COUNT / ROW PCT / COL PCT / TOT PCT	IWF 1.	WM 2.	W C 3.	WFC 4.	WMC 5.	WFM 6.	TWOMC 7.	FMC 8.	TWOMF 9.	TWOC 10.	ROW TOTAL
SUBADULT	0.	3	3	2	2	0	5	0	0	5	3	33
		9.1	9.1	6.1	6.1	0.0	15.2	0.0	0.0	15.2	9.1	38.8
		23.1	30.0	25.0	22.2	0.0	100.0	0.0	0.0	100.0	75.0	
		3.5	3.5	2.4	2.4	0.0	5.9	0.0	0.0	5.9	3.5	
ADULT	1.	10	7	6	7	7	0	2	2	0	1	52
		19.2	13.5	11.5	13.5	13.5	0.0	3.8	3.8	0.0	1.9	61.2
		76.9	70.0	75.0	77.8	100.0	0.0	100.0	100.0	0.0	25.0	
		11.8	8.2	7.1	8.2	8.2	0.0	2.4	2.4	0.0	1.2	
	COLUMN TOTAL	13	10	8	9	7	5	2	2	5	4	85
		15.3	11.8	9.4	10.6	8.2	5.9	2.4	2.4	5.9	4.7	100.0

AGE	COUNT / ROW PCT / COL PCT / TOT PCT	IFCS 11.	MCS 12.	FMCS 13.	ROW TOTAL
SUBADULT	0.	0	0	10	33
		0.0	0.0	30.3	38.8
		0.0	0.0	83.3	
		0.0	0.0	11.8	
ADULT	1.	4	4	2	52
		7.7	7.7	3.8	61.2
		100.0	100.0	16.7	
		4.7	4.7	2.4	
	COLUMN TOTAL	4	4	12	85
		4.7	4.7	14.1	100.0

CHI SQUARE = 43.40172 WITH 12 DEGREES OF FREEDOM SIGNIFICANCE = 0.0000

NUMBER OF MISSING OBSERVATIONS = 217

APPENDIX VI

TABLE 54

Crosstabulation By Age and Ossuary

AGE	COUNT / ROW PCT / COL PCT / TOT PCT	VAR015 0.	VAR015 1.	ROW TOTAL
SUBADULT	0.	88	21	109
		80.7	19.3	36.1
		34.2	46.7	
		29.1	7.0	
ADULT	1.	169	24	193
		87.6	12.4	63.9
		65.8	53.3	
		56.0	7.9	
	COLUMN TOTAL	257	45	302
		85.1	14.9	100.0

CORRECTED CHI SQUARE = 2.05286 WITH 1 DEGREE OF FREEDOM. SIGNIFICANCE = 0.1519
RAW CHI SQUARE = 2.56325 WITH 1 DEGREE OF FREEDOM. SIGNIFICANCE = 0.1094

APPENDIX VII

DATA FOR ANALYSIS OF BURIAL TYPES*

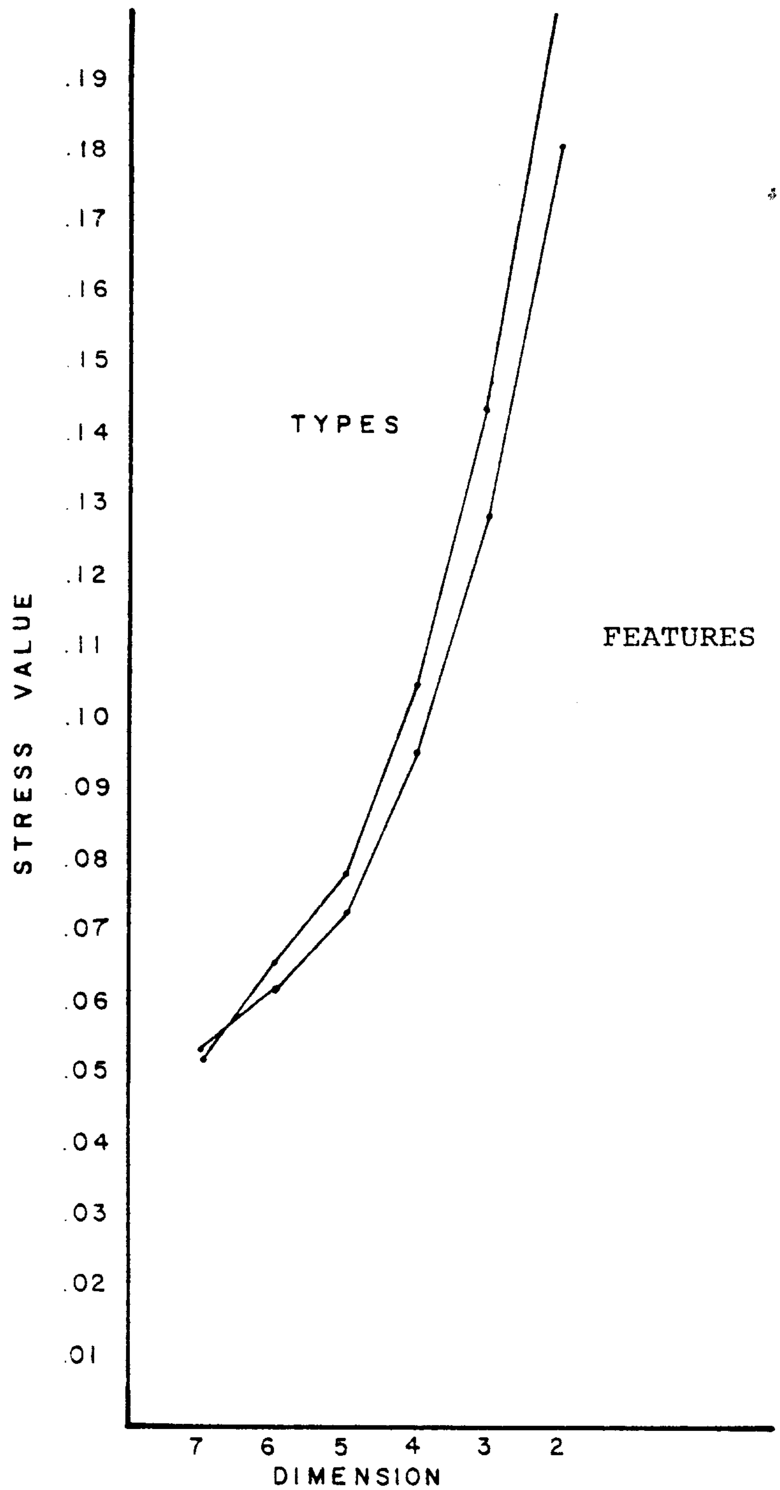

Figure 17. Torsca-9 stress plot for burial types and tumuli features.

APPENDIX VIIb

TABLE 55

Varimax Rotated Configuration Values for Burial Types

Tumuli	Dimension 1	2	3	4	5
PO 165	-0.679	-0.003	0.049	-0.076	0.012
BE 137	-0.064	0.171	-0.393	-0.054	-0.054
DA 237	0.149	1.073	-0.255	0.005	0.217
DA 216	-0.743	0.017	0.148	-0.044	-0.018
HI 30	-0.224	-0.116	0.514	-0.036	0.036
PO 301	-0.747	0.003	0.123	-0.059	-0.020
SR 138	0.038	-0.166	-0.160	-0.195	-0.395
CE 190	-0.128	-0.099	0.586	-0.181	-0.013
HI 135	0.348	-0.297	-0.743	-0.030	0.315
BE 6-4	-0.067	0.158	-0.399	-0.069	-0.050
HE 139	0.032	-0.204	-0.016	0.328	-0.004
HI 30c	-0.308	-0.046	0.539	0.058	0.100
PO 305	0.137	1.067	-0.263	0.011	0.243
CE 148	0.200	-0.115	0.013	0.075	-0.353
CE 150	0.237	-0.145	0.056	0.369	-0.142
CE 152	-0.201	-0.278	-0.416	0.029	-0.149
CE 154	-0.389	0.189	0.209	-0.027	-0.623
DA 222	0.202	-0.286	0.119	-0.117	-0.040
DA 225	0.227	-0.195	0.125	-0.087	-0.217
DA 226	0.267	-0.107	0.129	-0.265	-0.300
DA 246	0.017	-0.137	0.584	-0.164	0.127
PO 306	0.212	0.178	-0.046	0.294	-0.151
BE 6-1	0.169	-0.363	-0.026	0.081	-0.071
BE 6-2	0.101	0.206	0.007	-0.240	0.376
BE 6-3	-0.132	0.183	-0.322	-0.079	0.250
BE 3	0.086	-0.125	0.066	-0.173	0.490

APPENDIX VIIb

TABLE 55: Continued

Varimax Rotated Configuration Values for Burial Types

Tumuli	Dimension 1	2	3	4	5
BE 128	0.122	0.165	0.024	-0.167	0.448
BE 117	-0.140	-0.123	0.579	-0.186	-0.010
BE 118	0.531	-0.328	-0.605	0.195	0.312
BE 135	0.159	-0.291	0.010	0.066	0.092
BE 136	0.022	-0.176	-0.164	-0.184	-0.395
CE 104	-0.128	-0.322	0.088	0.052	0.230
CE 122	0.076	-0.218	0.080	-0.067	0.429
CE 123	0.125	0.208	-0.187	-0.232	-0.347
CE 198	-0.317	0.065	0.188	-0.686	0.135
DA 201	0.006	-0.312	0.239	-0.203	0.084
HI 149	0.408	-0.123	-0.658	0.020	-0.187
SR 111	-0.748	-0.010	0.130	-0.038	-0.002
SR 141	0.468	-0.011	0.807	0.221	0.273
HE 150	-0.146	-0.026	0.408	0.415	0.248
PO 300	0.128	0.314	-0.254	-0.297	-0.092
PO 307	0.052	-0.131	-0.033	0.370	-0.263
PO 304	0.292	0.354	-0.496	0.416	0.296
DA 250	0.320	0.156	-0.223	0.166	-0.907
DA 219	0.079	-0.246	0.170	-0.327	0.203
HE 147	0.027	0.188	-0.328	-0.040	-0.244
DA 221	-0.078	0.303	-0.003	1.152	0.128

APPENDIX VIII

TABLE 56

Varimax Rotated Configuration Values
For Tumuli Features

Tumuli	Dimension 1	2	3	4	5
HI 18	0.270	-0.778	-0.121	0.045	-0.231
PO 305	0.721	0.253	-0.158	0.299	0.074
CE 152	-0.517	0.149	0.130	-0.005	-0.059
CE 154	-0.019	0.339	-0.011	-0.088	-0.313
DA 225	0.085	0.133	-0.012	-0.260	0.582
DA 226	-0.263	0.056	0.668	0.047	0.067
PO 306	-0.178	0.297	-0.006	-0.060	-0.113
BE 6-2	-0.295	-0.277	0.020	0.109	-0.119
BE 6-3	0.434	-0.403	-0.213	-0.115	-0.305
BE 3	-0.131	0.252	-0.103	-0.385	0.097
BE 6-1	-0.515	0.184	0.098	0.049	-0.000
DA 246	-0.537	0.099	0.055	0.039	-0.025
DA 222	-0.492	0.139	0.172	0.110	-0.024
CE 150	-0.432	0.203	-0.015	0.313	0.174
CE 148	0.072	0.177	-0.069	-0.136	0.584
BE 128	-0.498	0.126	0.116	0.154	0.041
BE 117	0.014	0.298	0.282	-0.078	-0.205
BE 118	-0.449	0.089	0.454	0.091	-0.010
BE 135	-0.371	0.317	-0.029	0.278	0.041
BE 136	0.123	0.344	-0.075	0.353	0.089
CE 104	0.441	-0.040	0.164	0.218	-0.122
CE 122	0.023	0.163	-0.399	-0.523	0.198
CE 123	-0.166	-0.426	0.232	0.101	-0.143
CE 190	-0.030	0.311	-0.518	-0.094	-0.157
CE 198	0.144	0.128	0.276	-0.545	0.177
DA 201	-0.511	0.069	-0.596	0.116	0.116

APPENDIX VIII

TABLE 56

Varimax Rotated Configuration Values
For Tumuli Features

Tumuli	Dimension 1	2	3	4	5
HI 149	0.711	0.256	-0.079	-0.006	0.311
SR 111	-0.228	0.159	0.615	0.077	-0.079
SR 138	-0.523	0.090	0.096	0.108	-0.036
SR 141	-0.277	0.002	0.660	0.075	0.062
HE 150	0.069	-0.803	-0.065	0.083	-0.199
PO 300	-0.083	0.403	-0.069	0.155	-0.071
PO 301	-0.252	-0.221	0.002	0.063	-0.174
PO 307	0.258	0.355	-0.015	0.196	0.260
HI 30	0.436	-0.227	-0.131	-0.519	-0.120
PO 304	0.219	-0.846	-0.050	0.030	-0.095
DA 250	0.357	0.168	-0.214	-0.692	0.169
DA 216	0.468	-0.202	-0.144	-0.168	-0.436
DA 237	0.660	-0.159	-0.125	0.162	-0.011
DA 219	-0.011	0.335	-0.017	0.001	-0.361
BE 137	0.236	-0.072	-0.434	0.302	0.140
HE 147	0.154	-0.861	-0.091	0.024	-0.062
PO 165	0.194	-0.836	-0.131	0.131	-0.052
DA 221	0.688	0.257	-0.149	-0.057	0.341

APPENDIX IX

Dental Analysis Data

APPENDIX IXa

TABLE 57

Molnar's Tooth Wear Scoring Technique
(Molnar, 1971a)

MOLAR WEAR

Category of Wear	Description
1	Unworn
2	Wear facets, no observable dentine.
3	Cusp pattern partially or completely obliterated; small dentine patches.
4	Three or more small dentine patches with limited coalescing of patches.
5	Three or more large dentine patches with at least two completely coalesced; secondary dentine none to slight.
6	Complete coalescence of all dentine patches into one large patch; secondary dentine moderate to intensive; entire tooth completely ringed by enamel.
7	Crown worn away on at least one side; extensive secondary dentine.
8	Roots functioning in occlusal surface.

APPENDIX IXb

TABLE 58

List of Measurements Used in the Dental Analysis

Measurement	Source
Mandibular length[+]	
Mandibular height[+]	
Symphyseal height	W. Bass (1971)
Maxilla length	
Maxilla breadth	
Buccal-lingual tooth diameter	
Length of mandibular condyle	
Breadth of mandibular condyle	
Height of anterior coronoid process[+]	E. Scott (1974)
Coronoid notch depth	
Recession of alveolar bone	

[+]Used osteometric board

APPENDIX IXc

TABLE 59

Unrotated Factor Loadings and Explained Variance

	Factor 1		Factor 2		Factor 3	
	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla
Explained Variance (%)	43.0	52.9	15.5	20.4	11.2	11.1
(1) LM3	.54	.56	-.54	.63	.42	.42
(2) LM2	.76	.75	-.29	.11	-.22	-.56
(3) LM1	.83	.82	-.29	.24	-.23	-.16
(4) LPM2	.62	.79	.49	-.48	-.10	.09
(5) LPM1	.57	.59	.22	-.51	-.47	.26
(6) RM3	.63	.27	-.09	.89	.60	.30
(7) RM2	.71	.78	-.17	.23	.11	-.47
(8) RM1	.77	.91	-.16	.14	-.30	-.09
(9) RPM2	.56	.82	.59	-.43	-.37	.14
(10) RPM1	.47	.78	.63	-.17	.09	.44

APPENDIX IXc

TABLE 59: Continued

Unrotated Factor Loadings and Explained Variance

OROFACIAL METRICS

	Factor 1	Factor 2	Factor 3
Explained Variance (%)	47.8	17.5	13.6
(1) Maxilla length	-.03	.83	.33
(2) Maxilla breadth	.45	-.62	.28
(3) Mandible length	.79	-.17	-.37
(4) Mandible height	.90	.08	.14
(5) Symphysis height	.67	-.18	-.59
(6) Condyle length	.65	-.21	.63
(7) Condyle breadth	.45	.55	-.35
(8) Coronoid height	.91	.22	.16
(9) Coronoid notch depth	.87	.20	.05

APPENDIX IXd

TABLE 60

Varimax Rotated Factor Loadings, Explained Variance and Communalities

	Factor 1		Factor 2		Factor 3		Percent Communality	
	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla
Explained Variance (%)	28.6	33.2	21.4	21.3	19.7	30.0		
(1) LM3	.27	.19	-.13	.89	.82	-.20	75.6	87.7
(2) LM2	.77	.19	.07	.04	.33	-.92	71.2	88.0
(3) LM1	.84	.34	.09	.37	.36	-.71	83.6	75.5
(4) LPM2	.39	.85	.69	-.07	.02	-.36	63.1	85.9
(5) LPM1	.65	.81	.37	-.07	-.18	-.10	59.3	67.5
(6) RM3	.11	-.21	.33	.95	.80	-.15	75.8	96.0
(7) RM2	.50	.18	.21	.19	.50	-.90	54.8	87.2
(8) RM1	.80	.48	.17	.36	.21	-.70	70.7	84.7
(9) RPM2	.03	.87	.84	.01	.30	-.36	79.8	88.4
(10) RPM1	.12	.82	.78	.35	.02	-.16	62.5	83.2

OROFACIAL METRICS

	Factor 1	Factor 2	Factor 3	Percent Communality
Explained Variance (%)	31.6	17.4	30.0	
(1) Maxilla length	.12	.87	.18	79.7
(2) Maxilla breadth	.58	-.57	-.05	56.0
(3) Mandible length	.34	-.22	-.79	78.7
(4) Mandible height	.74	.10	-.53	83.6
(5) Symphysis height	.10	-.25	-.86	82.0
(6) Condyle length	.92	-.12	.02	85.9
(7) Condyle breadth	.04	.50	-.62	63.2
(8) Coronoid height	.75	.25	-.54	91.2
(9) Coronoid notch depth	.64	.21	-.59	80.3

APPENDIX IXe

TABLE 61

Unrotated and Rotated Factor Scores

UNROTATED

	Factor 1			Factor 2			Factor 3		
	Mandible	Maxilla	Orofacial	Mandible	Maxilla	Orofacial	Mandible	Maxilla	Orofacial
PO 300 2	1.55	.83	.93	.45	- .54	.19	1.01	-.83	-.13
HE 147 1	- .78	-	-	2.00	-	-	.85	-	-
2	1.20	1.06	-.73	1.41	-.27	-2.70	.26	-.32	-.62
BE 137 1	.11	-	-.85	-.48	-	.23	-.67	-	1.07
PO 307 2	1.50	-.12	-	-.20	1.89	-	.51	-.31	-
4a	-.97	-.33	-.85	.63	-.45	.65	-.72	.73	-2.29
6	-.97	-	-	.25	-	-	1.68	-	-
CE 150 1a	-.77	-.77	-.60	.54	-2.58	2.28	-1.05	-.65	-.45
3	-.70	-1.79	1.84	-1.06	.48	-.64	-1.31	-1.28	-.69
6	-.96	-.66	1.00	.80	1.10	-.49	-1.15	1.25	.06
7	.77	1.11	1.41	.90	1.09	.17	-.41	.98	1.09
DA 225 1	1.46	1.78	.51	-1.11	-.35	.02	-2.37	-1.15	.25
DA 226 1	-1.56	-	-	-.15	-	-	.95	-	-
DA 246 3	.01	-	-	-.04	-	-	-.74	-	-
4	.76	-	-.13	.07	-	.11	-1.04	-	.73
HE 150 1	-	-1.19	-	-	.67	-	-	-1.30	-
2	1.48	-	.55	-.15	-	-.11	1.71	-	-1.01
DA 201 1	-1.54	-	-	-1.76	-	-	.38	-	-
HE 139 2	.93	-	-	-2.23	-	-	.38	-	-
CE 122 2b	-.81	-	-	-.47	-	-	-.10	-	-
BE 128	-1.32	-	-1.83	-.41	-	-.65	.46	-	1.27
BE6 1 2a	-.13	-	-	-1.12	-	-	1.20	-	-
BE6 2 1a	-	.02	-	-	.14	-	-	-.64	-
3	-.15	-1.22	-	.32	.09	-	.23	1.35	-
4	-	.23	-	-	-.14	-	-	-.13	-
PO 306 4	.48	-	.34	-.93	-	.93	.92	-	.77
5a	-.27	-.44	-1.05	.86	-1.39	.05	-.93	1.97	-1.14
5b	-	-.02	-	-	.15	-	-	-.43	-
6a	.70	1.51	-.53	1.61	.10	-.03	-.05	.31	1.10

VARIMAX ROTATED

	Factor 1			Factor 2			Factor 3		
	Mandible	Maxilla	Orofacial	Mandible	Maxilla	Orofacial	Mandible	Maxilla	Orofacial
PO 300 2	.39	.50	.57	1.31	-.58	.17	1.33	-1.04	-.75
HE 147 1	-1.63	-	-	1.51	-	-	-.60	-	-
2	.35	.72	-.68	1.83	-.03	-2.76	.17	-.87	.32
BE 137 1	.63	-	.09	-.49	-	.37	-.25	-	1.33
PO 307 2	.83	-1.34	-	.62	1.27	-	1.21	-.53	-
4a	-.42	.37	-2.25	-.05	-.07	.32	-1.30	.34	-1.11
6	-1.83	-	-	.07	-	-	.69	-	-

APPENDIX IXe

TABLE 61: Continued

Unrotated and Rotated Factor Scores

	Factor 1			Factor 2			Factor 3		
	Mandible	Maxilla	Orofacial	Mandible	Maxilla	Orofacial	Mandible	Maxilla	Orofacial
CE 150 1a	-.05	.71	-.97	-.09	-2.61	2.20	-1.41	.58	-.13
3	.59	-2.06	.92	-1.49	-.90	-.72	-.87	.17	-1.70
6	-.19	-.53	.81	.02	1.31	-.47	-1.69	1.11	-.59
7	.58	.54	1.75	1.06	1.74	.32	-.32	-.26	-.21
DA 225 1	2.84	.89	.53	-.72	-.30	.05	-.59	-1.94	-.17
DA 226 1	-1.77	-	-	-.44	-	-	-.11	-	-
DA 246 3	.48	-	-	-.17	-	-	-.54	-	-
4	1.20	-	.39	.22	-	.21	-.44	-	.61
HE 150 1	-	-1.77	-	-	-.56	-	-	-.28	-
2	.05	-	-.28	.89	-	-.25	2.09	-	-1.10
DA 201 1	-.91	-	-	-2.17	-	-	.29	-	-
HE 139 2	1.03	-	-	-1.41	-	-	1.70	-	-
CE 122 2b	-.41	-	-	-.80	-	-	-.27	-	-
BE 128 2	-1.15	-	-.39	-.89	-	-.48	-.13	-	2.24
BE6 1 2a	-.55	-	-	-.80	-	-	1.33	-	-
BE6 2 1a	-	-.35	-	-	-.22	-	-	-.50	-
3	-.34	-.27	-	.25	.39	-	-.04	1.76	-
4	-	.18	-	-	-.11	-	-	-.22	-
PO 306 4	.02	-	.68	-.40	-	1.03	1.33	-	.22
5a	.16	1.41	-1.54	.44	-.18	-.11	-1.20	1.99	-.10
5b	-	-.32	-	-	-.15	-	-	-.36	-
6	.13	1.32	.37	1.70	1.01	.12	-.39	-.44	1.16

APPENDIX IXf

TABLE 62

Eigenvalues for Principal Component Analysis

	Factor 1	Factor 2	Factor 3
Mandible B-L diameter	4.30	1.55	1.12
Maxilla B-L diameter	5.30	2.04	1.11
Orofacial metrics	4.30	1.58	1.23

APPENDIX IXg

TABLE 63

Statistics of the Discriminant Function Analysis:
Table of Correlations, F-Ratios and Probabilities for the Variables

	Correlation		F-Ratio		Probability	
	Mandible	Maxilla	Mandible+	Maxilla°	Mandible	Maxilla
(1) LM3	-.33	-.05	1.49	.02	.23	.88
(2) LM2	.06	.07	.06	.04	.81	.84
(3) LM1	.16	.24	.35	.56	.57	.53
(4) LPM2	.38	.08	2.11	.05	.16	.82
(5) LPM1	.44	.12	2.83	.14	.10	.71
(6) RM3	-.17	.10	.40	.09	.54	.77
(7) RM2	.07	-.06	.09	.03	.76	.86
(8) RM1	.01	.28	.03	.79	.86	.61
(9) RPM2	-.19	.36	.48	1.37	.50	.26
(10) RPM1	.31	.21	1.33	.44	.26	.53

APPENDIX IXg

TABLE 63: Continued

Statistics of the Discriminant Function Analysis:
Table of Correlations, F-Ratios and Probabilities for the Variables

OROFACIAL METRICS

	Correlation	F-Ratio*	Probability
(1) Maxilla length	.47	2.05	.17
(2) Maxilla breadth	-.21	.36	.57
(3) Mandible length	.52	2.53	.13
(4) Mandible height	.37	1.20	.29
(5) Symphysis height	.29	.71	.58
(6) Condyle length	.19	.28	.61
(7) Condyle breadth	.62	3.91	.07
(8) Coronoid height	.70	5.54	.03
(9) Coronoid notch depth	.59	3.47	.08

+DFB = 1; DFW - 23

°DFB = 1; DFW = 14

*DFB = 1; DFW = 13

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PART II.

A REVIEW OF OSAGE ETHNOHISTORY

by

Lisa C. Griffin

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The use of ethnohistory as a research tool has become more prevalent in the last decade. That is, the use of historical sources in anthropological research has become useful to both the ethnographer and the archeologist.

Ethnohistory of American Indians offers a unique data source. It provides information for a nebulous time period, where we have written accounts or descriptions of native groups before the ethnographic present. This allows a glimpse of a culture in a relatively native environment: that is, before the time of the reservation when most ethnographies were done on American Indian tribes. At the same time, historical data (I use this in reference to that which is not collected by anthropologists) does have several problems as a data base. First, most of the recorders were not trained anthropologists and hence had little concern for the cultural detail of anthropological facts. Identification of ethnic groups was often confused (see Hodge 1907 for the hundreds of different names for any single ethnic group), and little attention was paid to information on kinship, language, subsistence, material belongings, ethnic and inter-ethnic relationships, religious beliefs, etc. Secondly, many of the recorders were not trained historians and were not concerned with accurate names, places and dates. Any data collection in the early accounts was unsystematic and more of an inventory. With these problems in mind, historical criticism can be used to assess historical accounts, and anthropological data can be extracted from the sources.

An ethnohistorical study can be the tie that binds the historic and the prehistoric data. It leads us into the historical present and can help explain the models proposed for the archeological record. The examination of the historical record concerned with the Osage will hopefully shed some light on the prehistoric record and place the prehistoric data in a historical continuum.

Again, some caution is advised when using models of change gleaned from the historical record. Even the earliest accounts given of the Osage Indians cannot present a group untouched by Western culture. Long before any initial physical contact was made with any of the groups west of the Mississippi, the effects of Western culture had been felt by these tribes. Trade goods were in this area prior to French and Spanish occupation in the territory, and these trade goods had been incorporated into the material culture of the tribes. And pressures on hunting territories and game were being felt as displaced eastern tribes were being pushed farther and farther west.

Nonetheless, with a critical approach, the use of historical data concerning the Osage Indians can provide some documentation of changes in the subsistence and settlement patterns of a native group prior to their removal to the reservation.

Before an examination and explanation of change in subsistence and settlement patterns of the Osage, it is necessary to try and define the Osage as a group, both within themselves and in relation to other groups of American Indians. Ethnographic information gives us the detail on the Osage which is necessary to place them in their proper perspective, culturally and geographically.

One must keep in mind that intensive ethnological work was not done on the Osage until after 1900, several decades after their removal from their native habitation. By then, many of the traits of the Osage had been lost entirely in their forced acquisition of a Euro-American way of life.

The Osage have been classified by F. W. Hodge as

> the most important southern Siouan tribe of the Western division. Dorsey classed them under the name Shegia, in one group with the Omaha, Ponca, Kansa, and Quapaw, with whom they are supposed to have originally constituted a single body, living along the lower course of the Ohio River.
>
> Geographically speaking, the tribe consists of three bands: the Pahatsi or Great Osage, Asehta or Little Osage, and Santsukhdhi or Arkansas band. These appear to be comparatively modern, however, and the Osage recognize three more closely amalgamated divisions which seem from the traditional account of them to represent as many formerly independent tribes (Hodge 1907: 156).

The Osage had a kinship organization similar to that of the Omaha. The descent was patrilineal, and there was a prohibition of marriage between both the paternal and maternal sides. These clans performed the various functions of the tribe as a whole, with some responsible for decisions on war, others in charge of peace-making, while still others were in charge of manufacture of certain goods and the naming of children.

A general geographic locations will be given for the Osage. This will be refined and explained in more detail later on in the text. The Osage, both Big and Little, resided mainly in the state of Missouri as well as in adjacent parts of northern Arkansas. The Arkansas band referred to above broke from the Big Osage at a late date and can be subsumed under the name Big Osage unless otherwise specified. This is where their known villages were located, with the Little Osage located for a time with the Missouri Indians on the Missouri River, and the Big Osage in villages along the Osage River in southwest Missouri. They were midway between the eastern Woodlands and the Plains, and their geographic location allowed them to exploit a variety of resources, that is the Plains proper, prairie, and wooded plateau and upland (Voget 1974: 5). Any general geographic description that is given is static in nature. The Osage, if anything, were not static in their use of resources and in their movements over areas of land. Hunting, war parties and raiding parties, changes in inter-ethnic relationships, and a massive path from the east by White settlers and traders allowed the Osage to cover an extremely large tract of land. They were seen in hunting and raiding parties from the Plains of Texas and Oklahoma to settlements in northern Illinois. In addition, they moved from the wooded forests and uplands of the Ozarks up into the High Plains of the Upper Missouri. Changes in these patterns of movements will help to give a clearer picture of the complex changes occurring all over the western United States during the 18th and 19th centuries.

The Osage not only roamed over a large area but constituted a sizable population. From the population estimates given (see Table 1), the Osage appeared to maintain a stable population until the 1840's when there was a precipitous drop (approximately one-fifth) in population beginning with the 1843 census. From the mid-1800's to the 20th century the population declined rapidly due to the effects of disease, warfare and a declining food supply.

The Big and Little Osage were primarily a hunting people, though they did have specific village sites and supplemented their diet of meat with corn and various gathered foodstuffs. Their villages were composed of dome-shaped

lodges constructed of wood bark and mats of reed. Tixier, a traveler among the Osage in 1839-1840, gives a description of the lodges and details of construction and arrangement.

> Nion-Chow (Neosho) is composed of about thirty roomy huts irregularly laid out, the smaller ones, which are less numerous are built in the shape of a cone and their tops have a narrow opening to release the smoke. The single opening, closed by a buffalo skin or a reed mat lowered during the night, looks out toward the east. The larger ones, from forty to fifty feet long, from fifteen to eighteen feet high, and about twenty feet wide, are shaped as parallelograms, on top of which is a semi-cylindrical roof with two openings, one at each end, corresponding to the location of the fires inside. These huts are entered through two doors on the southern parts of the two sides, which always correspond to the east and west. Lengthwise the cabins are always parallel to the meridian.
>
> Both large and small are built of the same materials. Coarse planks and wide pieces of bark make up the walls as high as five or six feet; mats of reed and buffalo skins cover the roof and overlap the walls to keep out the rain (Tixier 1940: 116-117).

Osage villages were relatively permanent in nature, although a great portion of Osage time was spent away from their villages on the hunt. The villages were returned to for the planting and harvesting of the corn, along with being a more permanent residence for those members of the tribe who were too old or sick to accompany the regular hunting excursions. The villages did not, however, conform to the more permanent habitation of the Northern Plains village-dwelling groups, possibly because of a slightly milder climate and a less horticultural orientation.

Chapman points out that a comparison of descriptions of Osage house types between 1806 and 1907 shows a change from a lodge that was similar to some of the Eastern tribes to a lodge that was more similar to those tribes on the Plains. He states:

> The typical Osage house type in 1806 was a long oval or rectangular structure varying in length from thirty-six to one hundred feet. A ridge pole was placed in the crotches of center poles which were about twelve feet apart. Small poles were bent over the ridgepoles and tied to rows of stakes about five feet in height at the sides. The framework was bound together with horizontal poles giving it

a lattice work appearance, then it was covered with matting made of rushes. This type of house was basically similar to those found among the eastern tribes.

The most common house type in 1907, however, was the dome-shaped lodge made of bent poles, both ends placed in the ground, bound together and covered with canvas. The house had no ridgepole and was generally less than thirty-five feet in diameter. Earth and sod were piled around the sides about a foot high to keep out surface drainage. These houses resembled the ordinary sweatlodge that is common in the Plains Area (Chapman 1974: 18).

These changes in house structure may be indicative of the Osage's move towards the West. Their central location in relation to the Euro-American expansion and opening of the Missouri River and the far West forced them further and further west, relying more on the resources of the Plains.

The Osage were mounted hunters. The acquisition of the horse among any native Amerindian group has always assumed a great deal of importance in the ethnographic record. The horse was a sign of wealth, power, and prestige. According to Chapman, the Osage were using the horse by 1719, but Mathews points out that by inference they may have had the horse as early as 1682:

> But it has been said rather definitely that both the Pawnees and the Missourias had horses in 1682, the year they all came under the protection of Louis XIV. If the classical enemy of the Little Ones (Osages), the Pawnees, had horses at this time, and if their kinsmen of the Missourias had horses at this date, they, the Little Ones, must have had them. They come often in contact with their ancient enemy, both by accident and by design, and each tribe held prisoners of the other, at all times.... The Little Ones must have known about horses long before they saw them, and after seeing them, they must have acquired them either by capture from the Pawnees or got them in trade with the Missourias and the Kiowas (Mathews 1961: 126-127).

This indicates that the Osage were one of the first to acquire the horse and to perfect their skill in its use, as well as accommodate the horse into their "culture." The acquisition of the horse among the Amerindian groups is important for several reasons. First, it allowed a tremendous amount of mobility among those tribes that used horses. The Osage in particular were noted for their wide-ranging

contacts with other groups which would have been impossible without the use of the horse. Second, the horse changed hunting patterns, allowing groups to exploit different and more distant resources and to exploit those resources more efficiently. Third, the actual acquisition of the horse from both whites and other Indian tribes changed interethnic relationships and trading patterns. Horses were worth a great deal to the Osage, and if they could not acquire them by formal trading agreements, they would simply take them by raiding encampments. And finally, the horse had to be accommodated in any established subsistence and settlement pattern. They had to be tended to in order to insure that they would not be stolen or stray from their grazing area. During severe winters horses had to be fed, necessitating a nearness to some kind of forage and during other seasons there had to be plenty of pasturage for the herds.

The horse added to the Osage a certain degree of prestige and power in relation to surrounding ethnic groups. As mentioned above, their interethnic relationships changed drastically because of their skill and wealth with horses.

> They were probably mounted before their kinsmen, except the Missourias and perhaps the Kansas, and this only magnified their prowess and gave them definite security in their domain. In the next century they would ride wildly against their enemies of the west – the Pawnees, the Apaches and the Caddoans of the Red River – and against the Kiowas when they came south from the Black Hills and the Comanches when they came south after splintering from their Shoshonean folk (Mathews 1961: 127).

The Osage as mentioned above were mounted hunters. Hunting was their main subsistence activity, but it was supplemented by the cultivation of corn, beans and squash and the gathering of wild seeds, fruits and nuts. The Osage did not spend as much time cultivating crops as some of the more sedentary tribes along the Upper Missouri. As Pike noted in 1806 when comparing the Osage to the Kitkehaki Pawnees, they were "in point of cultivation . . . about equal to the Osages, raising a sufficiency of corn and pumpkins to afford a little thickening to their soup during the year" (Coues 1895: 533). The seasonal cycle of the Osage consisted of approximately one-quarter of the year (January, April and August) being spent in their villages. This time was spent planting and harvesting their supplementary crops and riding out the winter cold. In the spring and summer and the fall and early winter, they hunted buffalo. During late winter and early spring (February and March), they hunted bear and other animals for furs to use in trade and for their own needs.

Major George Sibley provides a description of the Osage subsistence pattern although it was well into historical times. It is a good summary of a well-established pattern and a good basis for any further discussion of change in the subsistence pattern of the Osage.

> They raise annually small crops of corn, beans and pumpkins, these they cultivate entirely with the hoe . . . Their crops are usually planted in April, and receive the dressing before they leave their villages for the summer hunt, in May. About the first week in August they return to their villages to gather their crops, which have been left unhoed and unfenced all season.
>
> Each family, if lucky, can save from ten to twenty bags of corn and beans, of a bushel and a half each; besides a quantity of dried pumpkins. On this they feast, with the dried meat saved in the summer, till September, when what remains is cached and they set out on the fall hunt, from which they return about Christmas. From that time, till some time in February or March, as the season happens to be mild or severe, they stay pretty much in their villages, making only short hunting excursions occasionally, and during that time they consume a greater part of their caches. In February or March the spring hunt commences; first the bear, and then the beaver hunt. This they pursue till planting time, when they return to their villages, pitch their crops and in May set out for their summer hunt, taking with them their residue, if any, of their corn, etc. This is the circle of an Osage life, thus it has been with very little variation these twelve years past. The game is very sensibly diminishing in the country, which these tribes inhabit; but has not yet become scarce. Its gradual diminution ... makes them more expert and industrious hunters and warriors ....
>
> I ought to have stated that these people derive a portion of their subsistence from the wild fruits their country abounds with. Walnuts, hazelnuts, pecans, acorns, grapes, plums, paapaws, persimmons, hog potatoes, and several other very nutritious roots .... They gather and preserve with care ... preparing many ... so ... they are really good eating (Sibley 1915: 46-47).

TABLE 1

Osage Population Counts (Hodge 1907: 158)

Year	Number of Osage	Source
1821	5,200 (4,200 Great Osage; 1,000 Little Osage)	Morse
1829	5,200	Porter
1843	4,102	U.S. Indian Office
1843	3,758 (exclusive of Black Dog's Band)	Schoolcraft
1877	3,001	U.S. Indian Office Census
1884	1,547	U.S. Indian Office Census
1886	1,582	U.S. Indian Office Census
1906	1,994	U.S. Indian Office Census

GENERAL SUBSISTENCE AND SETTLEMENT PATTERN

With a description of the Osage in an ethnographic sense an attempt can be made to describe a general subsistence and settlement pattern. From this description we can begin with the first reports of contact and proceed up to the reservation period trying to discern those changes that may have been taking place, and more importantly try to discover the reasons for those changes.

The following is a hypothetical statement of the Osage subsistence and settlement pattern:

1. The Osage lived primarily by the hunt with supplements of horticultural products and gathered wild foods.

a. The hunting for buffalo occurred during established seasons of the year and followed the movements and habits of the large bison herds.

b. Beaver, deer (smaller game in general) and bear were hunted at established seasons of the year for the purpose of personal use as well as for trade with the French, Spanish and Americans.

c. The planting of corn and other horticultural products was done in the small amount of time spent in the villages and was minimally productive.

d. Wild foods were gathered whether in the village or on the hunt according to the season of the year. Gathering of wild foods was used to supplement the diet since most of the corn was eaten "soft" by the Osage. Both the planting of corn and the gathering of wild foods were performed by women.

2. The Osage occupied and reoccupied established villages for the purpose of planting and harvesting crops. The villages were also utilized during the more severe months of winter, possibly to provide forage and protection for the horses. Villages were also places for the old and sick to stay during the long hunts, allowing them a certain degree of protection.

3. Hunting areas were well established and were reused from year to year. Hunting camps were often reused and trails were well marked. The types of shelters used while hunting were less permanent with the possible use of limestone caves, when hunting in the wooded Ozark area in southwest Missouri and northeast Arkansas.

This general pattern will be examined in as much detail as possible for each of the time periods discussed

in the following sections of the report. For purposes of historical accuracy and also because of the convenience of discussing the documentation, each period is identified according to the official occupation and rule at that particular span of time. Hence, the sections are as follows:

1. The period of French Exploration of Lower Missouri or Upper Louisiana as it was called.

2. The Spanish Regime in Upper Louisiana.

3. The American Louisiana Purchase.

The documentation concerning Osage subsistence and settlement is particularly scant during the early French exploration and increases immensely by the time the Spanish had governed the area. The Americans systematically explored and documented this vast area of land and provided accounts with more cultural detail than is available in the strictly military/bureaucratic accounts of the Spanish.

FRENCH EXPLORATION OF LOWER MISSOURI

The French were the first white men to have any formalized contact with the Osage Indians. Their desire to explore, exploit, and settle the vast and unknown Trans-Mississippi West began with Father Jacques Marquette and Louis Jolliet's discovery of the Missouri River in 1673. In fact, Marquette's map of 1673 locates the Osage Indians apparently on the Osage River.

> The French, led by intrepid pioneers, explorers, fur traders and missionaries, occupied the St. Lawrence basin, pushed their frontier to the Great Lakes, spread their empire between the English on the Atlantic coastal plains and the Spaniards in the Southwest, and began exploring and exploiting the vast Mississippi-Missouri Valley (Nasatir 1952:2).

The French were interested in finding a route through the continent which would open up trading with the Orient. In addition, they were also aware of the riches in furs to be found in the interior of this continent. There was also the hope of locating gold, that consistently desired and rare metal that could lift nations out of bankruptcy and give them a position of power in the European homeland.

Since the French were the first to discover the Missouri River and its environs, they were the first to understand exactly what would be involved in exploring the area. The most effective way to explore the area was by employing <u>coureurs de bois</u>. This particular breed of men were the ones who penetrated the most unknown areas, learned the

languages of the native inhabitants, married Indian women, traded and lived with the Indians in order to open the way for a more systematic exploration of an area. In fact, the coureurs de bois were a study in successful acculturation, aided by an ability to successfully communicate with two completely different cultures. The coureur de bois were the initial reason the French were so much more successful than the Spanish, since their tactics allowed a relative degree of friendliness from the native inhabitants. Any degree of friendliness that allowed passage through an area was desirable.

Etienne Veniard de Bourgmond was the first man to explore the Missouri in a detailed fashion, and he was the first to mention the Osage Indians with whom he stayed for a period of time. Unfortunately, he says relatively little about them.

> The Osage, as well as the Missouris, were allies and friends of the French. All their commerce, he intimated was in fur; they could offer the best furs of the Missouri region. These folk were not numerous, but their blood was good, and they were the most alert of the Indian nations (Nasatir 1952: 13).

Bourgmond ascended the Missouri River as far as the Arikara villages. He returned to France in 1719, but his description of this Louisiana territory was important to the policy makers back home. It became apparent to the French that the Spaniards had to be prevented from making further inroads into this area. Already these tribes were using horses obtained from the Spanish. A solution to this dilemma was a permanent settlement in this area in the form of a fortified post. Since the Spanish had no fortified post in the area and were far from any base when they were in the area, there was the possibility of driving the Spanish out of the area completely with some help from the Indians. The authorities in France felt that Bourgmond would be the logical choice for a commandant of the Missouri and Arkansas river territory.

While these decisions were being debated in France, another French explorer was making a sojourn into the Louisiana territory. Charles Claude du Tisne in 1719 visited the Missouris, Osages, Panis (Pawnees) and Padoucas (Comanches). He was the first official visitor to an Osage village "on a height of one and one-half leagues northwest of the river" (Nasatir 1952: 18). The Osage received him well but balked at the fact that he intended to visit the Panis villages. The Panis were known to be bitter enemies of the Osage and the possibility that du Tisne could be trading for guns was a direct threat to the Osage. However,

he made his way to the Panis (Pawnees) and continued on to the Padoucas (Comanche) with whom he hoped to secure a safe passage for the French into Spanish territory.

Du Tisne's extensive expedition in this area convinced the French of the definite need for a military or official post in this area. In 1723 Bourgmond built Fort d'Orleans on the north bank of the Missouri in present day Carroll County, Missouri (see Bray 1980 for a more thorough discussion of Fort d'Orleans). From this post, Bourgmond began his attempts to try and resolve the differences among the many tribes in this area in order to gain more control over the trading and to prevent unnecessary wars and bloodshed. Nonetheless, long held alliances and hatreds were established among the tribes of this area, both among themselves and between themselves and the French and Spanish in the region.

The French occupied this area until 1763 when they ceded the Louisiana Territory to the Spanish. Their relationships with the Indians had been productive for purposes of trade and in their search for a passage to the Orient. The Osage in particular maintained an allegiance to the French, despite the fact that they managed to maintain a state of near war in the Missouri-Kansas-Oklahoma area. As Nasatir states regarding the French in the Louisiana Territory:

> Thus by 1753 ... Frenchmen, be they voyageurs, traders, trappers, explorers (official or unofficial), Illinois or Canadians, had penetrated the whole trans-Mississippi West country and in a general way had made known the country contained in the watershed of the Mississippi-Missouri rivers. They had ascended practically every large branch of the Missouri to the mountains; they had set foot on most of the territory lying between the Mississippi and the Spanish border; they had reached the Rocky Mountains. But they lacked precise information concerning parts of that country. Not all the information procured by the explorers, traders, and trappers, either from Canada or from the Mississippi Valley, was made known to the officials in Louisiana (Nasatir 1952: 55-56).

The early documentation of the Osage by the French is scanty, especially in descriptions of their subsistence and settlements patterns. Nonetheless, we can glean a general pattern in regard to our hypothetical statement of Osage subsistence and settlement.

Marquette's map locates the Osage Indians on the Osage River. At this early date they have already firmly established themselves in the area that they will control

until their removal to the reservations. The early memoirs concerning the opening and exploration of the lower Missouri area all locate established Osage villages. The Little Osage are noted to be in villages on the Big Bend in the Missouri River and living in villages near the Missouri Indians. Big Osage are located in villages on the Osage River. The Osage in general are known to be the tribe in this area that is richest in furs. Bourgmont even goes so far as to assert that all their commerce is in furs.

Along with a constant reference to the Osage wealth in furs, there is also reference to the Osage richness in horses and slaves. Furs, horses, and slaves were their main commodities in relations with the French and the Spanish in the area. They obtained their horses primarily from raiding tribes to the west and south, who had been trading horses with the Spanish.

In addition to raiding the Comanches (Padoucas) and the Pawnees (Panis) for horses, they raided the Pawnees for slaves. The Illinois French were the ones interested in the slave trade, and they eagerly supplied the Osage with firearms in exchange for slaves.

> The French government disapproved of this traffic and ordered it stopped, but without success. Panis slaves became so common that the French adopted the names of Pani and slave as synonymous. Most affected by these slave raids were the Panis-Noirs in Oklahoma, the Pani-Maha in Nebraska, and perhaps also the Arikara (Nasatir 1952: 19).

The Osage at this point were ranging over large distances. They were raiding the tribes to the west of them, the Pawnees and Comanches, for slaves and horses which they in turn were selling to the French in Illinois on the eastern side of the Mississippi. Their central location allowed them access to those interested in slaves as well as access to those being made slaves. They were constantly concerned that the French would not establish peaceful trading relations with the Pawnees or Comanches for three principle reasons: (1) they (the French) could obtain Spanish horses directly from these tribes; (2) they would effectively try to stop the slave trade, since the French government did not condone the practice by any means; and (3) they would provide these tribes with firearms which could easily upset the balance of power which the Osage maintained in relation to these other tribes.

The Osage were expanding both north and south from their main base on the Osage River. The Little Osage had broken away and settled north along the Missouri River.

The Arkansas band of Osage also broke away during the initial French occupation of this area. This northern and southern expansion was probably a response to the French occupation and a desire to have closer contact with the traders. As Voget says, "The Osage under the stimulus of trade and raid (which provided some of the most important items for trade) expanded northeastwards, southwards, and westwards during the 18th century ...." (Voget 1974: 115).

Little mention is made in these early documents of any horticultural activities, and there is no mention of trade for any horticultural products. We are presented with a picture of the Osage as being widely roaming for purposes of trade and for the purpose of hunting. They appear to have had access to the prairies and high plains as well as the wooded hills of the Ozark plateau. Their intense drive for guns was probably not only for protection and military power, but to aid them in the hunt, making food more easily obtainable.

As mentioned previously, a great deal of the detailed information on the Indian tribes never reached the official files of the French. Those coureurs de bois and the other explorers and traders who lived among the Indians and probably knew the detailed life patterns of the Osage, never wrote it down, if they could write at all.

The information that was recorded is concerned primarily with the commercial interests and possibilities of the Osage in relation to the French. We cannot say to what degree the Osage were supplementing their diet with horticultural products or gathered wild foods. And their hunting patterns were not included in the documentation for this period. But we have a general picture of the Big and Little Osage as a primarily nomadic people who lived in known villages for periods of time between hunting and raiding expeditions. At this point, some time spent in the villages can be assumed to be devoted to at least the gathering of wild plants with the possibility of horticultural endeavors. They became quickly engrossed in the economy of the French and obviously found a degree of profit in raiding their established enemies, the Pawnees and Comanches, for horses and slaves which were traded to the French and to other Indian tribes. Their hunting of wild game was not only for purposes of subsistence, but also for purposes of trade. They were successful at the hunting of fur-bearing animals and were considered to be rich in furs.

In summary, the Osages' geographic position, their strength in numbers, and their ethnic relationships helped them to assume a powerful role as middleman between the French and other tribes further west. They allied themselves strongly at this point with the Missouri Indians,

whom the Little Osage lived near in their villages on the Missouri River. The Big Osages also had a close alliance with the Kansa Indians as well as a close alliance with one another. These alliances affected movements, since enemy territory could be defined vaguely in relationship to established alliances.

SPANISH REGIME

Though the French lost the interior of the North American continent to the Spanish, they managed to control this area for at least six years after it officially belonged to the Spanish. The French were actually still in charge of the area for those six years after the treaty had been signed and life in the Upper Louisiana territory went on much as before, with the established French traders still operating in this area.

The Spanish, when they finally decided to pursue their new frontiers, took a much more systematic and military approach to the area. Their initial plans included numerous posts along the Missouri, with well stocked stores. The French had indicated that the tribes in this area were all on the road to Santa Fe and some of them were hostile to the Spaniards. There was also the usual problem of the English wooing these tribes into trade and allegiances with them.

Ulloa, governor of this area, in order to check the British in the area, sent Captain Don Francisco Riu to regulate trade and negotiate with the Indians. Trade was open though all the traders had to apply for a trading license and renew it annually. Annual renewal forced them to descend to the main post and aided in enforcing trading regulations.

Surprisingly, the Spanish in their early period of sovereignty in this region were not at all aggressive as far as exploring the region more fully than the French, or establishing stronger dependencies on the part of Indian tribes in this area.

> From such trade licenses and the distribution of presents, the advance up the Missouri under the Spanish regime may best be illustrated. Riu licensed traders for the Panis, Pani-Topage, Pani-Maha, Kansas, Utes (Otoes), Big and Little Osages and Osages. The French had traded with all these tribes of the Missouri; hence the Spaniards had not gone far beyond the limits of their predecessors. One reason was suggested by St. Ange, who wrote, on April 18, 1768, 'that it was not my thought to wish to attract new nations. I would rather never see them' (Nasatir 1952: 66).

As late as 1771 the Spanish still continued to list the same tribes and had gone no farther than the Platte River, which is just as far as the French had ascended the Missouri River. The Spaniards' main concern at this point was the defense of their territory, since the Americans had acquired the land east of the Mississippi and the English were a threat from the North.

> During the war the Spaniards in St. Louis defensively confined their activities on the Missouri to keeping the loyalty of their Indians and preventing Indian outbreaks or treachery. Thus the Spanish Illinois country suffered economically, and in effect the English traders enjoyed a monopoly of trade on both sides of the Mississippi .... (Nasatir 1952: 71).

From the roving and adventurous conquistadors, the Spaniards had assumed a highly conservative and protective policy with little desire other than a noticeable profit.

The lack of concern about illegal trading in this area, combined with little interest in substantial exploration during the first twenty years of Spain's administration in this area, changed abruptly in the late 1780's. In the ever-widening and ever-changing spheres of influence in the North American continent, Spain was being pushed from all sides. As mentioned previously, the English were pushing from the North, and in fact had been openly and illegally trading with the Indians in Spanish territory. They also spoke openly of desiring an opening of the Missouri River farther west. The Russians were beginning to threaten Spain's Pacific territories and were moving quickly towards California. Spain was forced to become aggressive in her control and protection of the Spanish Illinois area, as the Upper Louisiana territory was still called. Spain at this point needed to assert itself within the areas it legally held, and it also needed to fortify itself. But before any of this could come about, Spain needed to more adequately explore her territory, assess her situation and enlist, more forcefully if necessary, the trade and control of the Indian tribes in this area. As early as 1766 the French were indicating that intensive exploration of this area was necessary for New Spain to flourish in the region.

> The commerce in peltry which has been flourishing for two years is going to take a fall on the arrival of the English in the Illinois country, if one does not seek to increase it by carrying the commerce into the northwest of Louisiana and the Northern part of the Mississippi River, regions that have been but little frequented up to this time on account of the ease with which one conducted

> commerce elsewhere and on account of the ferocity of the tribes and of the difficulty of navigating the Missouri.... It can no longer be put off now, if one wishes to have peltries, it is necessary to ascend it (Dubry to the Minister January 27, 1766 in Nasatir 1926: 15).

Already the English had successfully gained the trade and trust of many of the Indians in this area.

Spanish trading policy among the Indians changed in the years that Spain controlled this area. The transfer of ownership from France to Spain necessitated a "policy" on the part of the Spanish territorial government. Stringent control was the policy implemented by Captain Riu initially, but this was quickly changed to an essentially open market, as mentioned above.

Against this background and this change in administration, we are able to gather a bit more documentation on the Osage Indians. The more systematic approach of the Spanish provides us with the consistency and accuracy of government reports by post and fort commanders to the Governor General of this Spanish territory.

The Spaniards inherited a tribe that was used to interaction on a trading basis with Europeans. In fact, the Osage had become heavily dependent upon the trade goods provided them previously by the French and English and now the Spanish. They were located in 1770 along the Osage River. De Mezieres, a commander, wrote in 1770 to Unzaga to report on the condition of the Osage and their relationship to the other tribes in the area:

> And, although here the Osages appear haughty and bold, neither will they deny anything your Lordship may cause to be suggested to them by the Commander of Los Ylinneses; whom they respect and fear .... I ought to tell you that the Osages, living on the river of the same name, which empties into the Missouris, have from time immemorial been hostile to the Indians of this jurisdiction....their mutual enmity being more in evidence through talk than through actual hostilities; and the Osage being diverted in hunting to pay their creditors of Ylinvey, to which district they belong (Nasatir 1928: 38).

Under the Spanish regime the Osage maintained their powerful position as the force that had to be controlled in order to open up the Missouri River for exploration and trade. Their subsistence and settlement patterns were changing slightly. The Spanish, for one, did not participate

in the slave trade which had been quite lucrative for the Osage during French control of the area. They did manage to continue their trading and raiding of horses.

The push from Eastern tribes was becoming greater. The Spanish had little tolerance for Osage antics and began to enlist the help of other tribes in trying to abolish the Osage. "Early in January, 1773, Unzaga gave permission to De Mezieres to allow the Indians (?) to mobilize and attempt to destroy the criminal Osages, if he deemed it necessary, and if such could be done without cost to the royal treasury" (Nasatir 1926: 45).

The Osage, both Big and Little, at the time of the Spanish reign in this area, still were not mentioned as having agriculture, while tribes around them were noted for horticultural practices. If, as can be hypothesized, the Osage were not engaged in any form of agriculture, then any push from other tribes into their area could be viewed as a direct threat to Osage livelihood and a cause for raiding and pillaging with even greater vengeance. If hunting was their principle means of subsistence, it required access and control over certain areas at certain times of the year. The report quoted at length below gives a clear description of the Big Osage and Little Osage, and it has no mention of agricultural practices (from a Report of the Indian Tribes Who Receive Presents at St. Louis, Dated November 15, 1777):

> <u>Little Osages</u>:
>
> The tribe of the Little Osages is composed ...of three hundred and fifty or four hundred warriors.... Their location is one-half league from the shore of the Missouri River, distant some eighty-five leagues from this village. Their occupation has always been and is, that of the hunt, whence comes the fur trade that is carried on at this post.
>
> ...since this race is so extremely warlike, that for consideration of a horse that one steals from the other they break peace entirely....Their work or occupation is sufficiently profitable for the fur-trade. The only harm...from this tribe in these settlements is the theft of some horses from the inhabitants, but one can usually succeed quite easily in inducing them to restore such animals (Houck 1909: 142).

Cruzat also gives a description of the Big Osage which is similar to that of the Little Osage, except for the larger number of warriors, i.e. population in general.

<u>The Big Osages</u>:

> This tribe is composed of eight hundred warriors. The name of the principal chief of this tribe is Cleromon. They are located one hundred and eighty leagues from this village by water, and about one hundred and ten overland, on the banks of a river emptying into the Missouri of about one hundred and forty leagues in length....The injury experienced from this tribe is the theft of some horses from the inhabitants of these settlements. Their occupation has always been that of the hunt, from which great profits result to the trade of this post; for every year this tribe produces five hundred or five hundred and fifty packs of deerskins (Houck 1909: 144-45).

It is interesting to note that these summaries contain no mention of agriculture among the Osage, yet they mention small amounts of horticulture among tribes with whom the Osage were living, hunting and raiding. The <u>Misuris</u> (Missouris), for instance, are described as people whose "occupation has always been, and is, that of the hunt, for although they generally plant a small quantity of maize each year, it is not sufficient even for their own support" (Houck 1909: 142). The <u>Cances</u> (Kansas) Indians are also cited as being primarily a hunting people with a small supporting quantity of maize. Both of these tribes had at times friendly relationships with the Osage Indians. The Panis (Pawnees), on the other hand, with whom the Osage were constantly at war were noted not only for their hunting but for their more extensive cultivation of horticultural products. "This tribe (Pawnees) gave considerable time to the cultivation of maize, and , therefore, they can be easily reduced to the cultivation of any other product" (Houck 1909: 142).

The hunt then during the late 1700's was still the main subsistence activity of the Osage. Those tribes nearby, with the exception of the Pawnee, cultivated a small amount of maize, which the Osage could have traded or stolen. Their locations, which can be assumed to be their main villages, were probably used as a gathering point for the tribe and as a place for the old and the sick. Locations of villages were probably also determined by their accessibility to traders, since all of the tribes of this area, especially the Osage, were in the grasp of the fur trade economy. A supplement to their diet was probably those foodstuffs which could be gathered in the immediate area, whether around the village or around the encampment area during the hunt.

From the beginning of the Spanish regime in this area, the Osage had been valuable as far as suppliers of food, but they remained a constant threat to the few white inhabitants of the area. The constant raiding and harassment by the Osage was stressing Spanish Indian policies. A letter dated 1790 to Miró claimed that the Osage were the most profitable to trade with:

> Juan Bautista Pratte, having arrived at this town, I have given him the trade of the Maha nation because of its being the best that remained after that of the Osages....This appointment, and our inability to send traders to the two Osage nations, which are the best of the Missouri nations for trade, are the reasons that many persons have not been satisfied this year....(Nasatir 1952: 134).

The Osage controlled this area and remained in control of the trade going up the Missouri River. This posed a constant problem for the Spanish and they decided to cut off the Osage from all trade until they became more agreeable to Spanish traders. This only presented more problems, since the Osage felt free to raid any traders for the goods they desired, or to shift their trade to the English or Americans, who would have been happy to gain such a strong foothold in this Spanish land. Since the abolition of trade among the Osage only created more conflict and raiding on the part of the Osage, it was decided to allow a fort to be built by the Chouteaus (Don Renato Augusto specifically) in exchange for their exclusive right of trade among this tribe. This was a big step on the part of the Spanish, but settlement or trade in this area could not be accomplished until the Osage nations were subdued. In 1795 Carondelet wrote to Las Casas, summarizing the events which had taken place in relation to the "perfidious" Osage.

> Most Excellent Sir: The settlements in upper Lusiana, and even the interior provinces, have been disquieted by the frequent assassinations and robberies which have been committed by the Great and Little Osages, who are located on the river of the same name toward the west....and this nation were extending their incursions as far as Nuevo Madrid, Arkansas, Natchitoches, and even the interior provinces, and kept their inhabitants in such a state of terror that they hardly ventured to leave the villages and estates in order to cultivate the fields or hunt....In consequence, I prohibited every kind of trade and commerce with both nations of the Osages, with the object of depriving them of the means of acquiring firearms and ammunitions....
>
> While I was awaiting the effect which these measures would produce the minister of the French Convention,

> Monsieur Genet began to assemble on the Ohio the expedition which was to invade Luisiana by way of the Upper Mississippi; and, not doubting that our enemies would avail themselves of this opportunity to receive the support of the Osage nations....
>
> I was previously informed by the said Lieutenant Governor of Ilinoa, Don Zenon Trudeau, that a habitant of San Luis named Don Renato Augusto Chouteau – a rich man, very friendly to the name of Spaniard, and held in high esteem by those savages, among whom he and his brother had lived in the early part of their career – has offered to erect a fort upon a hill which dominates all the vast plain in which the Osage dwell, on condition that the exclusive trade with those savages be granted to him during six years....(Houck 1909: 100-101).

The entrance of the Chouteaus into the Spanish period was the beginning of a monopoly on Osage trade. Nonetheless, they were successful at subduing the Osage. They stopped their murderous pillaging against Spanish settlements.

The Spanish period documents some aspects of Osage subsistence and settlement along with some changes that accompanied the change in administration and the ever-increasing trade in the Osages' native habitation.

First the Osage continued to live mainly by hunting. Due to the large area that they hunted in, they partly depended for their success on the acquisition of horses. This they accomplished by raiding other Indian tribes, primarily the Pawnee and Comanche, and by raiding white settlements. Sainte Genevieve in particular is mentioned as constantly being subjected to Osage raids, and the Osage had been hostile to Spanish settlements prior to their governing the Illinois area. The Spanish claim that the Osage had been raiding their interior provinces indicates that the Osage may have been raiding the Spanish settlements for horses rather than always having to raid the Pawnee and Comanche. "...the Big and Little Osages who were hostile for years back to our settlements of the upper Misisipi (<u>sic</u>), as well as to the interior provinces (Note by Houck: Provencias Internas, or Interior Provinces, being the northern provinces of Nueva Vizcaya, Coahuila, Texas, New Mexico, S. Naloa and Sonora and the Californias, because they were in the interior as regarded from the City of Mexico)" (Houck 1909: 110). The Osage dependence on the horse for hunting determined many of their movements and their relationships with both the Spanish and other Indian tribes.

Since they depended on the hunt for their subsistence, we can infer that a great deal of attention was paid to seasonal movements of animals; Osage settlements were necessarily moved as different kinds of game were exploited. Their wide-ranging territory suggests the use of both small game and the large bison herds to the west. Not much mention is made of any specific seasonal rounds or hunting habits since the Spanish were primarily concerned with control of the Osage.

There is still no mention of agriculture being pursued by the Osage, although there is mention of agricultural practices among the other tribes in the same area. Either the Spanish officials chose to ignore it, which is doubtful, or the Osage were not pursuing the cultivation of corn and other products which is more likely. They were no doubt aware of maize and squash as a foodstuff, and these horticultural products may have been an additional reason for raiding other tribes. The Pawnee, with whom they were notorious enemies, were also successful farmers, according to the Spanish. Just as the nomadic, warlike Sioux in the north were raiding the villages of the Mandan, Hidatsa and Arikara for corn, the Osage may also have made similar raids on the Pawnee in order to supplement their diet with corn. There is also no explicit description of the gathering of wild foodstuffs by the Osage, though one can assume that since gathering was a prehistoric occupation among these peoples, it was probably done as systematically as ever; it just was not noted. The Spanish had a much more military/economic approach to these Indians and control and defense seemed to be their main goal. More explicit information on horticulture and gathering of wild foodstuffs is available in later documents.

The Big and Little Osage lived in established villages. In the 1770's the Little Osage were still on the Missouri River with Missouri Indians. The Big Osage were located in their villages in Vernon County on the Osage River. By 1790 the Little Osage had rejoined the Big Osage on the Osage River and had established a village in close proximity.

There appears to have been general movement toward the west by the Osage, and although the Little Osage had moved down from the Missouri, the Osage in general were beginning to split up and move west for purposes of trade and hunting. White Hair's band moved to the Arkansas drainage thereby splitting the tribe in two. As Chapman states in his discussion of Indian hunting territories

> There is one report that an Osage band or village under Chief Big Track moved to the Verdigris River (Oklahoma) in 1796. Another group or perhaps the same one, (approximately one-half of the Missouri

> or White Hair Osage) moved to the Arkansas drainage in 1802 in order to continue trading with the Chouteaus. At this time the break between the Arkansas Osage under the leadership of Clermont and the Missouri Osage under the leadership of White Hair was complete (Chapman 1974: 206).

The Osage by the time of American sovereignty in this area were moving farther from the centers of population and farther from the centers of control. No descriptions are provided of hunting camps, hunting trails or other types of settlement used by the Osage. We assume later documents can be extrapolated back to this period with some variation in settlement pattern.

The Osages relationships with the other tribes in this area remained pretty much the same. They were antagonistic toward the Pawnee and Comanche, but they remained allies with the Missouri and the Kansas, though they still desired to stop traders from visiting their allies if they were to be denied trade. The Spanish policy relative to some interethnic relationships was to try to control the Osage by sending other tribes to war against them. Although initially this seemed a good idea, it meant that the Indian tribes would be fighting each other instead of providing the Spanish with valuable peltries. And the Spanish really had little control over already established relationships, which were and always had been very fluid. The Spanish also had little control over the other European nations that were trading in the surrounding areas. In 1791 Perez wrote to Carondolet, the Spanish governor, explaining this situation:

> For the others to make war upon the Osages would not achieve any other advantage than cause us immense expense. The Sacs and Foxes who are the strongest, and from whom something might be hoped, have recently made peace and have sent a large party to the Missouri to hunt with them [Osages], after some Osages had been in the Sac nation, who gave them some merchandise obtained from the English merchants who are in the other district (Nasatir 1952: 150).

The Osage, at the time of the Louisiana Purchase and intense exploration by the Americans, remained in control of a vast area of land. Trade was the only means of coercion and many times the Osage held the upper hand. It was in the next century that the Osage would make the enormous adjustments which eventually led to life on a reservation.

THE AMERICANS' LOUISIANA PURCHASE

Thomas Jefferson had been interested in the Missouri River for a long time before the Americans were actually in possession of this territory. So when an unprecedented purchase was negotiated with the French in 1803, giving the United States the exclusive rights to the area occupied by the Osage, the Americans were ready to intensively explore and settle this area.

The first major expedition into this area was the Lewis and Clark expedition, set up for the purpose of documenting the geography and inhabitants of this area, as well as locating a passage to the Pacific Ocean. This was followed by innumerable other expeditions, along with the establishment of the Office of Indian Affairs under the Secretary of War. The Office of Indian Affairs had regional superintendencies (specifically one at St. Louis); under the superintendents were Indian agents at various posts in Indian territory, each assigned to specific tribes with whom they were to control trade and help to negotiate treaties.

We begin in this period to see some distinctive changes in the Osage subsistence and settlement patterns. The split of the Osage tribe is documented in the Lewis and Clark journals:

> June 1, 1804. The Osage River gives or owes its name to a nation inhabiting its banks at a considerable distance from this place....They number between twelve and thirteen hundred warriors, and consist of three tribes: The Great Osage, of about five hundred warriors, living in a village on the south bank of the river – The Little Osages, of nearly half that number, residing at the distance of six miles from them – and the Arkansan band, a colony of Osages, of six hundred warriors, who left them some years ago, under the command of a chief called Big Foot, and settled on the Vermillion River, a branch of the Arkansas (Biddle 1962: 5).

There is a larger and larger push from displaced tribes of the east to use this Louisiana territory as a base from which to exploit its resources. The white populations are also becoming more numerous since St. Louis has been an established city almost since the settlement of the New World. This probably accounts partially for the splintering of the Osage, since they could probably more efficiently exploit this area if they moved a section of the tribe (in this case nearly half) to a new area. It may also be the case that the Osage, having a fairly substantial population with the Little Osage rejoining them in the area of the Osage River in Vernon County, were budding off in a way

which they probably had on numerous occasions before they had ever been recorded by white men. The immediate catchment area for these people was probably of necessity increasing in size. Rather than change entire subsistence strategies, it was easier to simply move and exploit a new area. Moving to a new area was still possible for these people, a fact which would not be true in less than a generation. The Osage did, regardless of the split, still regard themselves as Osage.

The United States government, nevertheless, wanted to assemble the Osage together, in order to be able to keep track of and better control the Osage, who had begun to assume a position of centrality between St. Louis and the rest of the Indian populations on the Missouri. Peter Chouteau had been appointed as the Indian Agent for the Upper Louisiana and received from the Secretary of War in 1804 a directive to reunite the Osages:

> ...you will take the earliest opportunity for healing the breach between the Osage nation and the party under Big Track, and endeavor to prevail on the latter with his partisans to return to the nation and to live in harmony.
>
> You will take the necessary measures for obtaining permission of the Big-track and his party for the safe passage of any party which may be sent by the President of the United States to explore the sources of the Arkansas river and the interior country generally bordering on the waters of Red River, the Arkansas and the Southwestern branches of the Missouri (Carter 1948: 32).

In the early years of United States administration in this area, the Osage maintained their independence and declared in several instances that they had no allegiance to the United States. Regardless of a benevolent policy towards the Indians, the Osage continued their harassment of settlers in the area as well as other Indian tribes. In 1808 Governor Lewis wrote to the Secretary of War to express his concern over the Osage situation:

> The Big Tracks band of the Great Osage on the Arkansas river have not been much less active in depridations on our frontier than those on the Osage river, within the last eighteen months they have killed one of our citizens and stolen a number of our horses. Their hostile disposition towards us at present is such that I have refused all applications for licenses to trade with them... (Carter 1948: 198).

This situation in 1808 is the beginning of an entirely new policy for the Indians west of the Mississippi – the idea of a treaty in which the Osage would actually cede land to the United States. The United States government was concerned with the legality of their purchase from France and also needed some more concrete way to control the Osage nation.

> By these arrangements, we shall also obtain a tract of country west of our present settlements and East of the hunting boundary of the Osage, sufficient for the purpose of our white Hunters, and for such Indian Nations, as has long been on terms of intimate friendship with us. Thus, will our Frontier be strengthened and secured, with the least possible expense to the government.
>
> The establishment of a boundary line has long been desirable; and the want of one, settled by Treaty, has never ceased to create doubts, and sometimes embarrassments of the most serious nature, in our courts of justice (Carter 1948: 229-230).

A more detailed subsistence and settlement pattern emerges with the beginning of the 19th century. There is consistent mention of rather erratic horticulture, along with indications of the seasonal round of the Osage. The great distance covered by the Osage in 1815 reveals a definite trend towards the western resources, along with a schedule of their agricultural products. Chouteau, their Indian Agent, seems eager to be able to leave the area as soon as the Osage leave:

> ...Osages are not stationary. Hunger compels them to follow the Herds of Buffaloes and other animals for subsistence some time at the distance of Six hundred Miles, from whence they return about the time of planting and gathering corn. Should the agent be at the village when they are gone he certainly would run the risk of being killed or at least plundered by other tribes who very often in the summer destroy the cabbins and crops of the Osages....visit them twice a year to wit, in April and August as those Indians return from their wintering hunts about the middle of March to Plant corn, leave their village in the first part of May and return again towards the end of July and abandon it sometime in September after gathering their corn (Carter 1951, Vol. 15: 99).

In the early 1800's to about the 1830's the Osage are firmly entrenched in hunting and minor agricultural pursuits in the area of Arkansas River in both Oklahoma and

Kansas. In 1806 and 1807, Zebulon Montgomery Pike made an expedition down the Arkansas River and his references to the Osage are numerous in relation to hunting grounds and their temporary encampments used while hunting. While just east of Arkansas City, Kansas, Lt. Wilkenson of the Pike expedition notes:

> ...on this stream [the Salt Fork] the Grand and Little Osages form their temporary fall hunting-camps, and take their peltries. When the severity of winter sets in, the Grand Osages retire to Grosse Isle on the Verdigrise or Wasetihoge and the Little Osages to one of its small branches called Porsitonga, where they remain during the hard weather and thence return to their towns on Neska or Osage river (Coues 1895, Vol. 2: 555).

Captain John R. Bell of the Long Expedition provides us with more detail on the temporary encampments of the Osage in the area of the Arkansas River. In these there is mention of small gardens at these temporary encampments exhibiting

> ...a more permanent aspect than three others that occurred on our route of the three past days; much bark covered the boweries; and a few pumpkins, watermelons, and some maize, the seeds of which had fallen from unknown hands, were fortuitously growing as well within as without the rude frail tenements (Thwaites 1905, Vol. 16: 240).

Bell also describes a more extensive settlement or hunting encampment ofthe Osage. If indeed this is a hunting camp, then the Osage must have by the 1820's firmly established themselves in this area of the Arkansas River in the Kansas-Oklahoma area. This particular settlement is on the Kansas-Oklahoma line.

> ...large cabins enclosed and covered with pieces of bark - the pens for securing the horses in the Village was intire (sic) and a number of poles and sticks was standing, understood by Indians and persons acquainted with their customs. It has no doubt been occupied this spring as paths in and about the camp had evidently been made since the spring vegetation. On the knobs or hills for miles around this camp was placed a pile of stones, where probably sentinels had been stationed... (Fuller and Hafen 1957: 237).

Bell's party finds hunting camps throughout this area, along with well-marked trails or "Indian traces." These all contained hunting camps along them and at one point he

met Osage scouts out looking for buffalo before the fall hunt. These trails not only were hunting trails, but one led to a trading post at the mouth of the Neosho River in Oklahoma.

The hunting of the buffalo became increasingly important to the Osage as they spread westward from the Wichita Mountains in Oklahoma to the Arkansas River drainage in Kansas. The buffalo migrated north out of the Texas Plains to an area immediately north of the great bend of the Arkansas River.

> Their most prized feeding ground was the section of country between the South Platte and Arkansas rivers, watered by the Republican, Smoky, Walnut, Pawnee, and other parallel or tributary streams, and generally known as the Republican country. Hundreds of thousands went south from here each winter, but hundreds of thousands remained. It was the chosen home of the buffalo (Hornaday 1887: 493).

The Osage, both Big and Little, followed the movements of buffalo closely. Since buffalo moved out of the southern Plains in the Spring, the Osage would sweep west after them on their spring and summer hunt. While the Osage were in the vicinity of the Great Bend of the Arkansas River for their spring buffalo hunt, they would also go to the Salt Plains to "harvest salt." These Salt Plains were an area controlled by the Osage, but coveted by the Comanche and Pawnee. Here the Osage had frequent skirmishes with these tribes.

> There is a considerable fork of the river there, and a kind of Savanna where the salt water is continually oozing out and spreading over the surface....During the dry summer season the salt may be raked up in large heaps....This place is not often frequented, on account of the danger from the Osage Indians (Dunbar 1904: 164).

After procuring salt and hunting buffalo, the Osage would return to their villages for a harvest of corn in late August. But not longer after the Osage harvested their rather meager crops, they were out again on a fall hunt. This fall-winter hunt is not as well documented in the historical record. The buffalo appear to break up into smaller herds and are farther west. The Osage were forced to move their hunting territory further west and disperse the hunting camps in order to make the hunt worthwhile.

> Fowler's evidence...forces the conclusion that in both summer and fall sufficient buffalo were

> accessible to the Osage only if they proceeded west of the 97th degree of longitude....The heaviest concentration of buffalo lay between the 98th and 99th parallels (Voget 1974: 280).

Jedediah Morse in his report to the Secretary of War in 1820 stresses the importance of hunting to the Osage as being their main subsistence. He also mentions their involvement in producing small crops of corn, beans and pumpkins. He is also the first one to talk about the cacheing of crops by the Osage, that is, producing enough to store until they return from the winter hunt.

> Each family, if lucky, can save from ten to twenty bags of corn and beans, of a bushel and a half each, besides a quantity of dried pumpkins. On this they feast...til September, when what remains is cashed (sic), and they set out on the fall hunt from which they return about Christmas (Morse, 1822: 205-207).

Pike, on the other hand, says that the Osage raise a "sufficiency of corn and pumpkins to afford a little thickening to their soup" (Coues 1895: 533). Even as late as 1867 "The Osage agent reports...that this tribe depends mainly on the hunt for support; the women plant small patches of corn and vegetables and hoe them over before going on the summer buffalo hunt; they eat most of the corn 'while soft' but cache part of it" (Will and Hyde 1917: 109).

Their growing corn and beans was less serious than the tribes of the Upper Missouri who stayed near their gardens until their crops were harvested. The Osage on the other hand left as soon as possible for the hunt. As long as the hunt was still possible and until they were forced into agriculture would the Osage seriously and successfully take up a sedentary lifeway.

The 1820's then showed some marked differences in Osage subsistence and settlement. From this time until the period of the reservation, the Osage began to fight their losing battle. Successive treaties with the United States ceded much of their land away. The eastern tribes were beginning to be resettled in the areas the Osage exploited in the Arkansas River drainage along with the presence of white hunters and trappers who had pushed them out of the Ozark Plateau. They began to attack these groups of traders/hunters, just as they had twenty or thirty years earlier on the Ozark Plateau. Their take on the hunt was getting smaller and smaller, and they were cited several times by Indian agents as being hungry.

By now the Osage had split into three main bands and had moved well into the Kansas River drainage and were recorded as having established hunting camps with small gardens and to have well-marked trails. They exploited the Great Salt Flats and controlled this salt resource in relation to other tribes and white traders. The slave trade had totally diminished though the Pawnee were still enemies of the Osage. There is very little mention of the Osage in the area of the Mississippi River. Their exploitative resources had moved west and they had ceded through treaty to the United States much of their lands east of the Ozark Plateau. The Osage still had little interest in agriculture and viewed it, even into the 1860's, as a supplement to their diet. It was never considered a main foodstuff nor a viable trade item.

The final blow to the powerful Osage was an act of Congress passed in July 1870 establishing the limits of their present reservation in Oklahoma. In 1906 it consisted of 1,470,058 acres, plus some income from Treasury funds and pasturage leases.

SUMMARY STATEMENT

This report has provided a distillation of the available evidence for an Osage subsistence and settlement pattern. I surmise that the hypothetical subsistence and settlement pattern for the Osage is a realistic summary of a pattern that was established at the time of contact and continued, with various changes, to the time of the reservation. The variations are important and need to be understood and studied in order to further our understanding of culture change in a contact situation. But they can be fit into the stated pattern.

This study, or ethnohistoric studies in general, can be illuminating to the archeological record. The Osage, as a tribe, were in this area before white contact. They were exploiting some of the same resources they exploited in historic times. With historical factors accounted for, the stated patterns can be used, if nothing else, to discuss change and the reasons for change.

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PART III.

ENVIRONMENTAL STUDIES

NUMBER 1.

LATE QUATERNARY GEOCHRONOLOGY OF THE LOWER POMME DE TERRE RIVER, MISSOURI

by

C. Vance Haynes

ABSTRACT

Fourteen consecutive field seasons of scientific excavations of alluvial deposits of the lower Pomme de Terre Valley, southeastern Missouri, have provided a radiocarbon-dated (145 analyses) chronostratigraphic sequence in four terraces reflecting five major episodes of aggradation and degradation during probably all of Wisconsian time and the Holocene. A sixth alluvial deposit is possibly Illinoian. Spring deposits within the terraces contain bone beds associated with peat lenses containing pollen, plant, and beetle remains, all of which have provided paleoecological data.

Initially, the springs appear to have emptied in response to either tectonic disturbance or hydrostatic pressure near the peak of a glacial maximum. Subsequent episodes may correlate with later maxima. Peat deposits correlate with interstadials on the bases of fauna, flora, and radiocarbon dating. Gravel deposits of spring conduits contain bones and plant remains that are considerably older than overlying peat deposits. Some of these older elements have been redeposited in younger spring deposits via spring action. Other evidence suggests that some animals may have fallen into springs and, therefore, intruded older deposits. A developmental sequence for the origin of concentric spring deposits in alluvium is proposed.

None of the six spring deposits excavated contained any associated archaeology older than 10,500 B.P., which marks the first appearance of artifacts in the stratigraphic record at Rodgers shelter. Extinction of the Pleistocene big-game animals occurred sometime between then and 16,000 B.P.

A major episode of degradation occurring between 10,500 and 13,000 B.P. probably coincides with similar episodes occurring approximately 12,000 B.P. on many if not most streams in the United States. Subsequent epicycles of cutting and filling appear to correlate generally over the same area but there are enough exceptions to maintain doubt.

PREFACE

In September 1965, I received a letter from W. Raymond Wood, then Director, River Basin Surveys, University of Missouri, asking if I would be interested in conducting geological work in conjunction with archaeological excavations to be conducted at a bluff site called Rodgers Shelter. Aside from the intriguing potential for Paleoindian occupation of the shelter, Wood offered more "bait" by saying "...about a mile south of the shelter, and in the same river valley, is the presumed locality of the Koch mastodon on the Pomme de Terre River." The potential for finding evidence for pre-Clovis Paleoindians was too good to pass up, but of further interest to me was the opportunity to work out the geochronology of the alluvial sequence in the subhumid unglaciated Ozark Highlands, well away from the arid and semiarid Southwest where most of my work on alluvial stratigraphy had been done (Haynes, 1968). The sites also happened to be near the childhood homes of a long-standing close friend and his wife who had impressed me with the surface collections of artifacts they had made there. So, in July 1966, Jerry and Carolyn Shelton and their two boys joined my wife, Taffy, daughter, Lisa, and me on a trip to the northern Ozarks where we joined Ray Wood and R. B. McMillan and we fell in love with the Pomme de Terre Valley.

Ray Wood and I also coaxed Peter J. Mehringer, Jr., into looking for fossil pollen there. Preferring spring bogs to alluvium, he cored Boney Spring and discovered, in addition to pollen, bone and tusk 4 m below the surface (Mehringer and others, 1968). The following summer we discovered the bone beds and peat deposits of both Boney and Trolinger Springs. By this time Bruce McMillan, who was conducting the excavations at Rodgers Shelter for his PhD dissertation, had already found abundant evidence of Paleoindian occupation as old as 10,500 B.P. (McMillan, 1971). Later, he established the true location of Koch Spring

which we excavated in 1971. We examined Jones Spring in 1966 (Fig. 6a) and tested it in 1971 when the lower peat was discovered.

James E. King took over the fossil pollen investigations in 1968, and with Bruce McMillan in 1973 we discovered the Phillips Spring site while backhoe trenching in the spring deposits. The vertebrate paleontological studies of Trolinger and Boney Spring were under the direction of Everett H. Lindsay, and Jeff J. Saunders, who studied the fauna of Boney Spring and conducted the paleontological excavations at both Jones and Trolinger Springs from 1971 to 1977 (Saunders, 1977a, 1977b), while Stephen Chomko (1976) and Marvin Kay (1980) excavated Phillips Spring.

Up to 1976 these investigations had been financially supported by the National Park Service and the National Science Foundation, but thereafter the U.S. Army Corps of Engineers has supported most of the work by contract with the University of Missouri, under the direction of first W. R. Wood and later Donna C. Roper.

My 14 years of participation in these investigations have been exceptionally rewarding. Close ties of friendship have been established with both the project's participants and the people of the area. And the avocational preservation of a pioneer log house has given me and my family a keen interest in the history of the area and some new roots. The Breshears Valley is our second home.

ACKNOWLEDGEMENTS

This work has been supported by the National Science Foundation with grants to University of Arizona, University of Missouri, Southern Methodist University, and Illinois State Museum, and by the U. S. Army Corp of Engineers, Kansas City District, with contracts to the Illinois State Museum and the University of Missouri. Personnel of the Corps of Engineers, H.S. Truman Reservoir Project, who were especially helpful are: Col. Griffith, Melvin A. Johnson, Roberta Comstock, Mary Lucido, Cecil Ryder, and Edward Elmoe. The Missouri Department of National Resources was very helpful in providing information and assistance in coring operations and completion of wells at Jones and Trolinger Springs.

Lasting friendships have been made with the many colleagues who have participated in the project and made my work possible. This includes Stanley A. Ahler, William H. Allen, David A. Baerreis, G. R. Brakenridge, Carl H. Chapman, Stephen A. Chomko, Donald L. Johnson, Marvin Kay, Gerald Kelso, Francis B. King, James E. King, Walter E. Klippel, Everett H. Lindsay, R. Bruce McMillan, Peter J. Mehringer, Jr., Michael V. Miller, Paul W. Parmalee, J. R. Purdue, Christine K. Robinson, Donna C. Roper, Jeffrey J. Saunders, Enst A. Stadler, Donna Watson Stegner, Ronald Ward, and W. Raymond Wood, who had the foresight to initiate the interdisciplinary studies of which this is only one part.

A major contribution of this work is the more than 130 stratigraphically controlled radiocarbon dates provided through cooperation with E. Mott Davis and Sam Valastro, Texas Memorial Museum; James B. Griffin, University of Michigan; Herbert Haas, Southern Methodist University; Austin Long, University of Arizona; Minze Stuiver, University of Washington; and E. R. Taylor, University of California, Riverside.

During the past decade and a half I have been assisted in one way or another by many citizens of Benton and Hickory counties, all of whom I consider close

friends. Unfortunately, space restrictions allow only a few to be mentioned specifically. Jack Rodgers always enthusiastically supported archaeological excavation of his rock shelter and helped several uninitiated visitors to the site extract vehicles that became stuck on wet days. For more than a decade Jesse Kaufman provided very skilled and reliable backhoe service. Homer Routh and Edsel Breshears did equally good work for us after Jess' retirement. Long time residents of the Avery area, Jake and Iva Bird, Iven and Goldina Trolinger, Ray and Lucille Sherman, Bob Kennedy, G. T. and Emma Blackwell, Francis Kirby, Harold Pippins, and Imogene Stuart Nazar provided a wealth of information on the history of the Breshears Valley and the locations of springs and archaeological sites. Their patience with the many --ologists excavating on their former farms is sincerely appreciated.

Others who helped in one way or another include Tommy Blackwell, Roy Butler, Robert Drake, Jim Henderson, David and Nancy Herbert, Chip Hyzer, Don Hotolling, Joe Kennedy, Lawrence Kennedy, Kenneth Lasswell, Henry and Kathleen Liedke, Donna Mann, John Salee, and Dillon Tipton.

Over the 14 field seasons in the Ozark Highland I have enjoyed working with many archaeological field crews and graduate students pursuing research in one discipline or another. Their enthusiasm and interest is a rewarding experience. A special word of appreciation is due Alison Habel for her expert drafting and Doris Sample for typing and preparation of the manuscript. Taffy and Lisa Haynes provided constant encouragement and lasting companionship throughout the project.

Preliminary versions of the typescript were read by G. R. Brakenridge, Donald L. Johnson, Marvin Kay, James E. King, Paul S. Martin, Jeffrey J. Saunders, and Michael R. Waters. Their comments were most helpful in improving the typescript.

LATE QUATERNARY GEOCHRONOLOGY OF THE LOWER POMME DE TERRE RIVER, MISSOURI

by

C. Vance Haynes

INTRODUCTION

In the valley of the lower Pomme de Terre River, Benton and Hickory Counties, Missouri there is an abandoned incised meander that forms an isolated valley in which the Henry and Alexander Breshears families made permanent settlement in 1838 (Fig. 1). Two years later they hosted Albert Koch, a German emigrant who collected fossil bones for his museum in St. Louis. He extracted mastodon bones from a spring less than 2 miles south of what is now called Breshears Valley. Some of the bones made up one of the finest mounted specimens of Mammut americanum known, and which may be seen today in the British Museum where it has been since 1844 (McMillan, 1976a).

Koch also found stone projectile points in the spring and believed therefore, that early man had a hand in the animal's demise. These factors, plus the discovery of artifacts in a stratified rock shelter on the nearby Rodgers farm, led to the scientific investigations which began in 1963 (Wood and McMillan, 1976). Since then the most complete record of geologic-climatic events in the mid-continent for the last 100,000 years has been determined. This has been accomplished over 15 field seasons by scientifically controlled excavations at the archaeological and paleontological sites. Skilled teams from the University of Missouri, the Illinois State Museum, and the University of Arizona have been responsible for the scientific investigations supported by funds from the National Science Foundation. Additional support from the U.S. Army Corps of Engineers

Figure 1. Panoramic view of the Breshears Valley looking eastward toward the Pomme de Terre Valley.

allowed backhoe trenching and core sampling of floodplain alluvium throughout the study area (Fig. 2). This proved invaluable in deciphering the complex and commonly subtle stratigraphy (Fig. 3). The stratigraphic framework of both riverine sediments and intricate spring deposits could not have been accurately defined without the use of stratigraphic trenches, because natural exposures are few and the succession of repeated lithologies makes it essential that contact relationships be observed in an adequately exposed and prepared section. It could not have been done by core sampling alone, which was most useful in determining the subsurface extent of stratigraphic units only after the framework had been worked out from the excavations.

The purpose of this paper is to present the stratigraphic framework from which the various fossil and archaeological finds can be related one to another and to radiocarbon dates and other samples. These relationships provide the basis for the reconstruction of the fluvial history of the Pomme de Terre Valley (Fig. 4a) and paleoenvironmental changes during the last 100,000 years (the late Quaternary period).

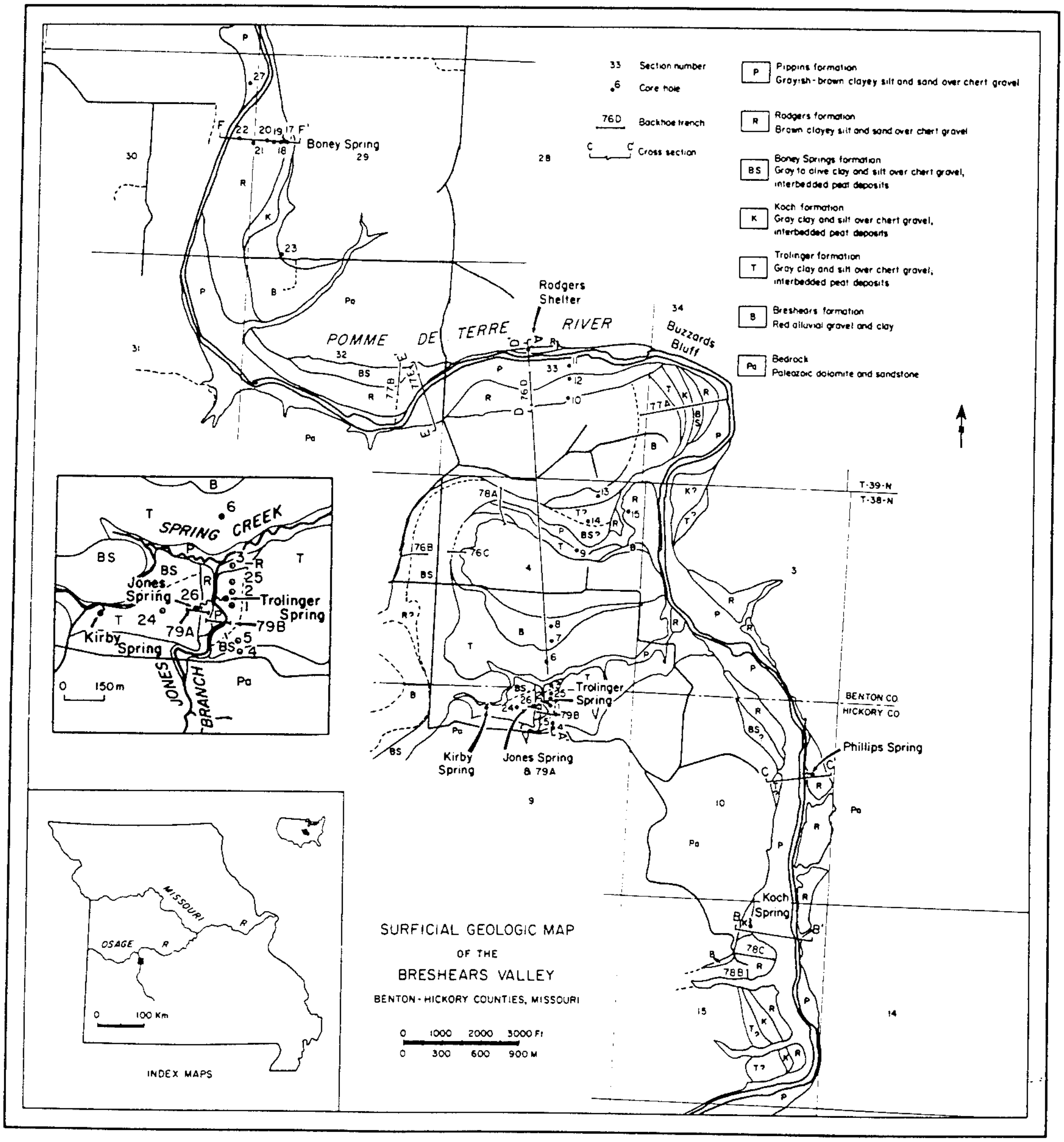


Figure 2. Alluvial geologic map of the lower Pomme de Terre River, Benton and Hickory counties, Missouri.

ALLUVIAL DEPOSITS

The important archaeological sites at Rodgers Shelter and Phillips Spring and paleontological sites at Koch, Boney, Trolinger, and Jones Springs all occur in deposits of three alluvial terraces (T-0, T-1, and T-2) which are further subdivided into alluvial cut-and-fill events (Fig. 3) dated by radiocarbon analysis. The stratigraphic framework as presently understood represents a significant revision of Haynes (1976, 1978) and Brakenridge (1979, 1981). In some places the terrace surfaces are so close in elevation and uneven that they cannot be distinguished on the basis of elevation alone especially if the contact between them has a low-angle dip. A fourth terrace (T-3) of possible pre-Sangamon age (Fig. 4b) is mainly a strath of oxidized chert gravels with a strong red, relict paleosol (Haynes, 1977) and is informally named the Breshears formation (Fig. 3). It has not been studied in detail, but its point bar deposits probably represent the last time the river meandered on the scale indicated by the incised meanders of the Pomme de Terre Valley. Soils on all of the alluvial deposits have been investigated by Johnson (1977, and others, this volume). Even older are relatively thin (<1 m) strath remnants and lag deposits of stream-rounded, tan-colored chert gravels on the higher, relatively flat surfaces of Paleozoic carbonate rocks that make up the Ozark Plateaus, as defined by Fenneman (1938). These deposits were abandoned by the ancestral Pomme de Terre as dissection of the Ozark Plateaus progressed. They have not been mapped in the study area and will be referred to simply as the older strath gravels as opposed to the strath gravels of the Breshears formation of T-3. The incision of the Pomme de Terre Valley into bedrock of Paleozoic dolomites and sandstones probably occurred throughout much of Pleistocene time.

Initially I defined four Quaternary alluvial units in the lower Pomme de Terre Valley and informally called them Koch, Boney Spring, Rodgers, and Pippins

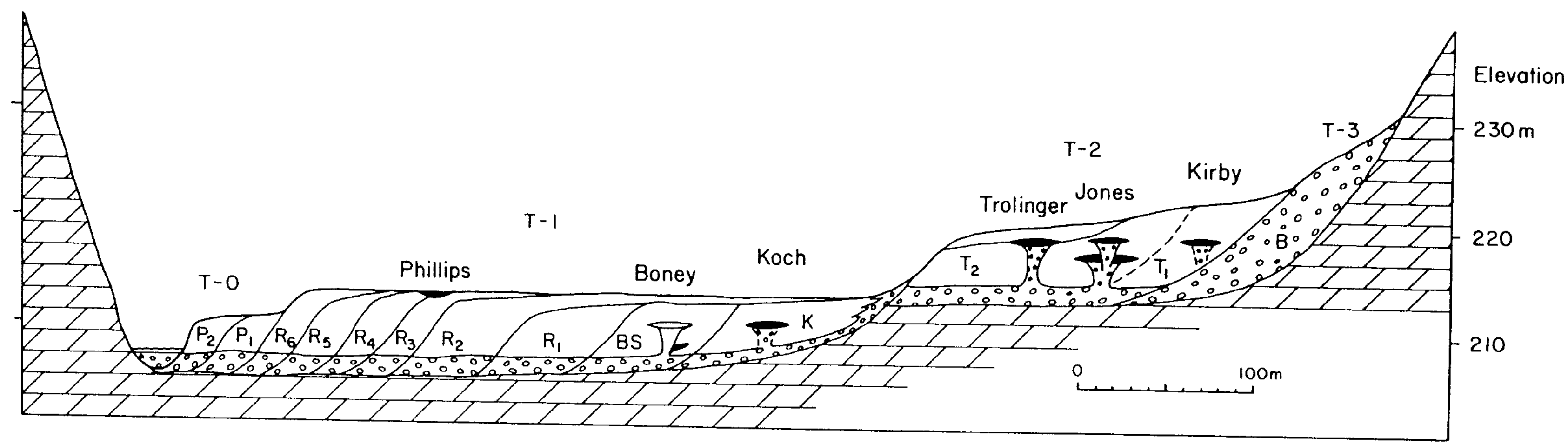


Figure 3. Generalized geologic section of alluvial terraces of the Pomme de Terre River.

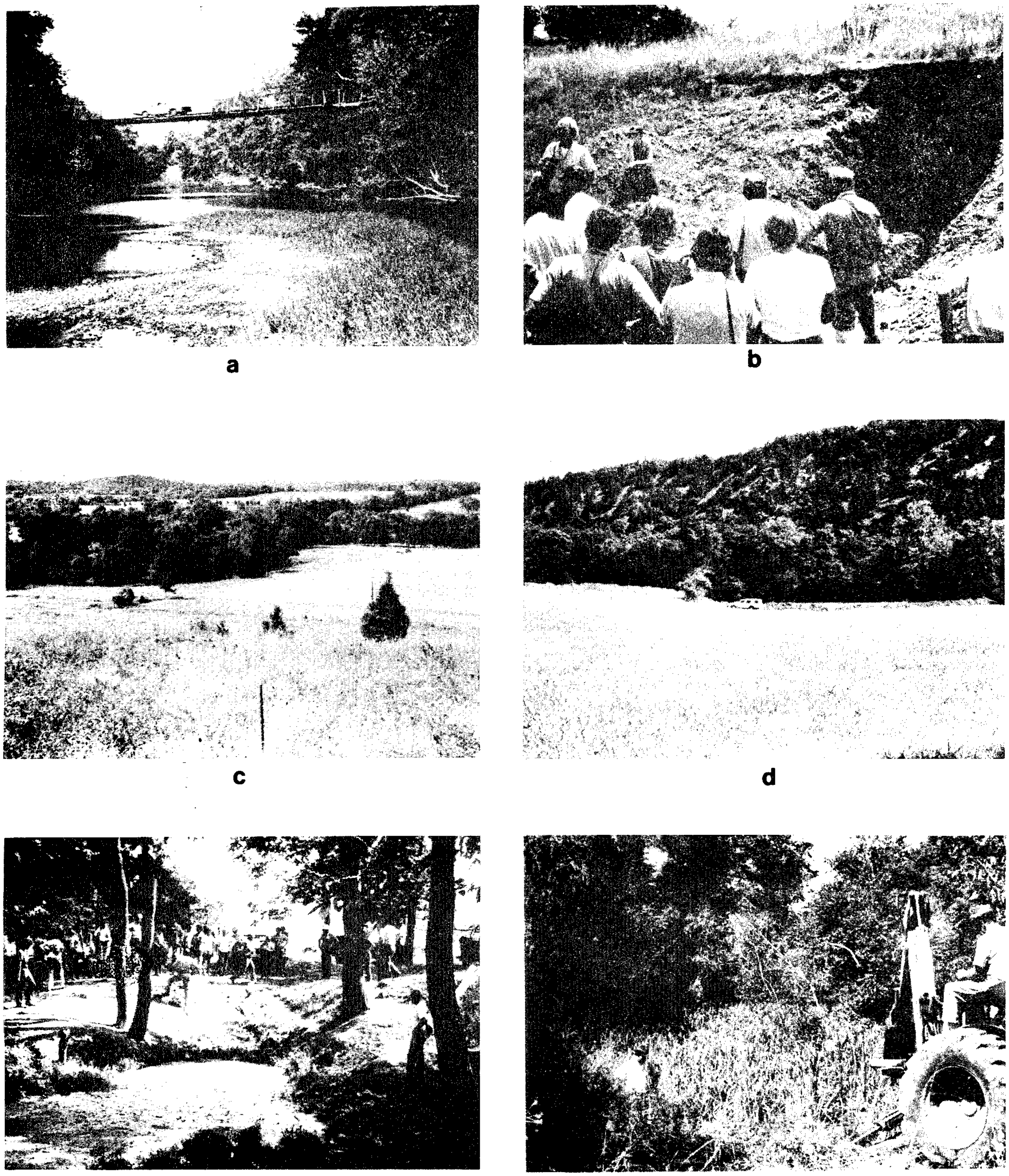


Figure 4. Views in the Pomme de Terre and Breshears Valleys.

alluvium (Haynes, 1978) ranging in age from late Pleistocene to Holocene. Later the deposits of T-3 were informally called the Breshears formation (Haynes, 1978). Brakenridge (1979, 1981) redefined the Koch alluvium and renamed that part in the Breshears Valley the Trolinger formation. The differences are discussed below.

Trolinger alluvium

The predominant alluvial deposit in the Breshears Valley (5Y 6/1 (dry), 4/4 moist), the Trolinger formation (T-2), is composed of about 9 m of gray silty clay and clayey silt with lesser proportions of clayey sand and gravel lenses, covering 1 to 2 m of subangular to subrounded chert gravel with a dark gray (reduced) patina. Fourteen core holes to bedrock showed Trolinger alluvium in the subserface throughout the Breshears Valley (Fig. 4c). Toward the surface, approximately 14 m above the modern streambed, the alluvium is gradational through a 10 to 20 cm mottled zone to brownish-yellow (10YR 6/8, 5/6) except where reducing conditions have been maintained around Trolinger, Kirby, and Jones Springs.

Throughout the Breshears Valley, Trolinger alluvium typically has a well developed dark gray soil (mollisol) (Johnson, 1977) developed on it that supported a bottomland prairie before European settlement (McMillan, 1976 b). This prairie may have attracted the first homesteaders to the valley because less clearing had to be done. The mollisol grades to a reddish-brown soil on the colluvial slopes around the periphery of the abandoned meander. The stratigraphic relationships were revealed by trench 76B (Fig. 5). Brakenridge (1979, 1981) considers the reddish brown alluvium therein to be Rodgers formation, but I believe the mollisol, which is stratigraphically higher, is much older than Rodgers alluvium, are probably due to wetting and drying in response to fluctuation of the water table.

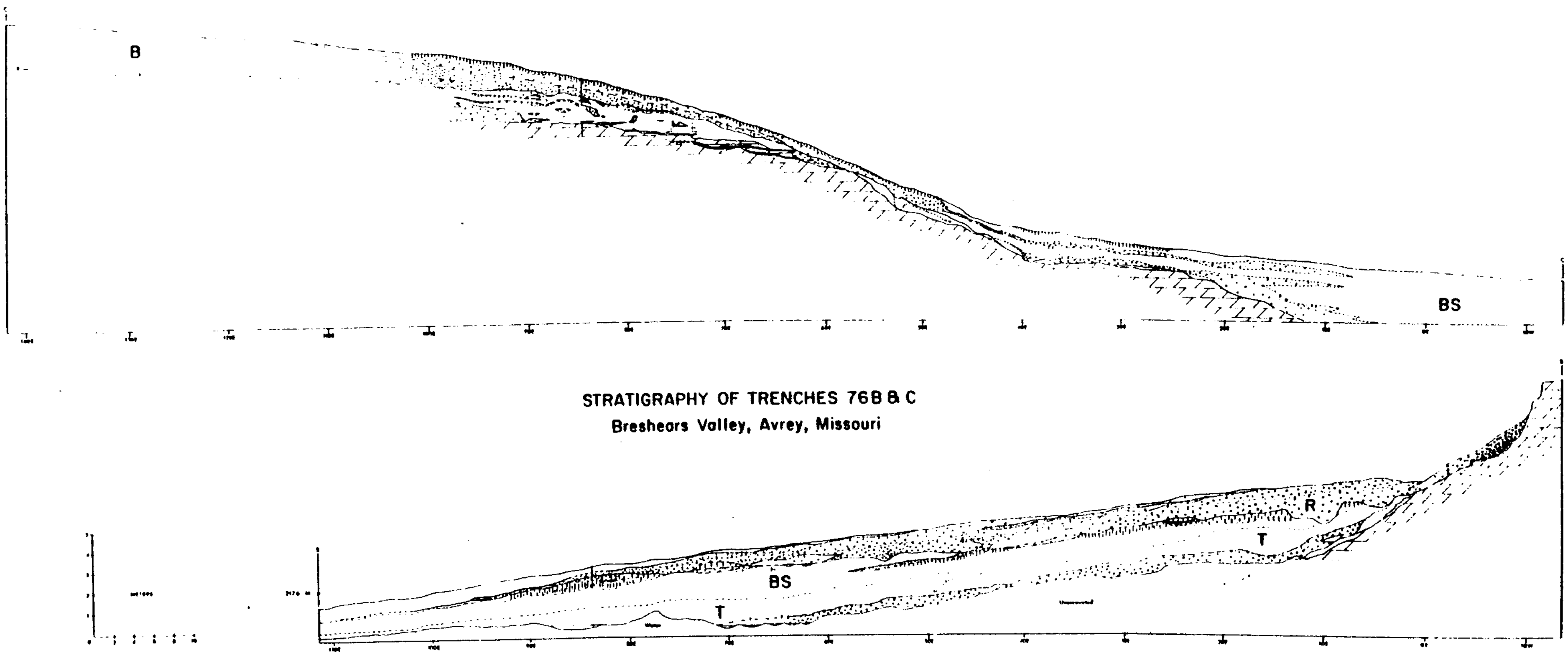


Figure 5. Stratigraphic profile of Trenches 76B and C.

Few remnants of the Trolinger formation remain outside of the Breshears Valley along the Pomme de Terre River. Trench 77A opposite Buzzards Bluff exposed a remnant about 9 m above the streambed that is mapped as Trolinger alluvium on the basis of its elevation and lithology (Brakenridge, 1979, 1981). Other occurrences (queried on Fig. 2) may exist in the mapped area but without adequate exposure or geochronological data they cannot be positively identified. About 2 km across the river and northwest of Boney Spring there appears to be more T-2 deposits in the remnant of another cutoff meander, and yet another such occurrence is across the river southwest of Fairfield (see U.S.G.S., Fristoe, 15-minute quadrangle).

Radiocarbon dating of well-preserved wood and plant fragments in Jones and Kirby Spring deposits, described later, indicate that all of the Trolinger formation is probably in excess of 35,000 years old (Table 1). At Jones Spring a finite radiocarbon date of 48,000 ± 900 B.P. (Q-L962) was obtained on a juniper (juniperous virginiana) log at the base of the upper third of the formation (Fig. 6c), and an experimental uranium-series date of 160,000 B.P. was obtained on mastodon tooth enamel from the same level (McKinney 1979).

Pollen analyses and plant remains from peat deposits at Jones and Trolinger Springs reveal an open, pine parkland for the Breshears Valley during the later depositional phase of Trolinger alluvium (King, 1973; King and Lindsay, 1976). Fossil bones from the peat deposits include mastodon, mammoth, horse, and bison, essentially a grazing fauna (Saunders, 1977a).

The basal gravels in the Breshears Valley are undoubtedly channel gravels from a time when the Pomme de Terre River flowed through the valley before the cutoff occurred. Core sampling in 1973 revealed up to 50 cm of a dark gray, organic clay between 8 and 9 m depth over the basal gravels in the southern part of the meander (Fig. 7, A-A^1). This suggests stagnant conditions possibly

TABLE 1. Radiocarbon dates in years before present (A.D. = 1950) arranged stratigraphically by site.

Formation	Radiocarbon date	(Lab. No.)	Material	Stratigraphic Position	Depth*
			Rodgers Shelter		
P_2	430±100	(A-867)	Charcoal	Late lower Pippins alluvium	
P_2	530± 70	(SMU-466)	Charcoal	Upper Stratum 4 (unit G_2)	1.13
R_6	1460± 60	(SMU-446)	Charcoal	Stratum 4, level 1	0.38
R_6	1390± 70	(SMU-438)	Charcoal	Stratum 4, level 2	0.53
R_6	1580± 70	(SMU-447)	Nuts	Stratum 4, level 2	0.53
R_5	2350± 80	(SMU-454)	Charcoal	Stratum 4, level 2	1.20
R_5	2250± 70	(SMU-478)	Charcoal	Stratum 4, level ?	1.28
R_5	2070± 70	(SMU-439)	Nuts	Stratum 4, level 3	0.69
R_5	2520± 60	(SMU-448)	Charcoal	Stratum 4, level 4	0.84
R_4	3360± 70	(SMU-510)	Charcoal	Stratum 4/3, level 6	1.14
R_4	3430± 50	(SMU-524)	Charcoal	Stratum 4/3, level ?	1.14
R_4	3530± 80	(SMU-451)	Charcoal	Stratum ?, level ?	1.43
R_3	5100±400	(M-2332)	Charcoal	Stratum 3, pit	1.37
R_3	5200±200	(M-2281)	Charcoal	Stratum 3, pit	1.37
R_2	6300±590	(ISGS-35)	?	Stratum 2, level ?	1.77
R_2	7010±160	(GAK-1171)	Charcoal	Stratum 2, level ?	3.20
R_2	8100±140	(GAK-1170)	Charcoal	Stratum 2, level ?	3.05
R_2	7490±170	(GAK-1172)	Charcoal	Stratum 2, level ?	3.44
R_2	7170±160	(SMU-502)	Charcoal	Stratum 2, level 11	1.90
R_2	7250±360	(SMU-507)	Charcoal	Stratum 2, level 12	2.06
R_1	8100±300	(A-868A)	Charcoal	Stratum 1, level ?	3.81
R_1	8030±300	(M-1900)	Charcoal	Stratum 1, level ?	4.52
R_1	10,530±650	(ISGS-481)	Charcoal	Stratum 1, level ?	8.53
R_1	10,200±330	(M-2333)	Charcoal	Stratum 1, level ?	8.98
			Rodgers Shelter Secondary Bone Carbonates		
?	105.38±2.92%M	(SMU-533)	Secondary CO_3	Stratum 4, level 4, bone	
R_2	280±160	(SMU-530)	Secondary CO_3	Stratum 2, level 11 & 12, bone	
R_2	117.97±2.09%M	(SMU-532)	Secondary CO_3	Stratum 2, level 16, bone	
R_1	121.23±1.71%M	(SMU-526)	Secondary CO_3	Stratum 1, level 18, bone	

Rodgers Shelter, West Terrace

P_1	200± 60 (SMU-456)	Charcoal	Stratum 4, unit G_2	2.05
P_1	200± 70 (SMU-467)	Charcoal	Intrusive pit in Strat 4	1.98
R_6	1060±100 (SMU-474)	Charcoal	?	2.21
R_5	1910±110 (SMU-455)	Charcoal	Stratum 4 ?	2.28
R_5	2620±150 (SMU-464)	Charcoal	Stratum 4/3, ?	2.44
R_3	5130±160 (SMU-459)	Charcoal	Stratum 2, ?	3.66
R_2	7960±130 (SMU-461)	Charcoal	Stratum 1, ?	4.57

Phillips Spring

P_2	270± 50 (SMU-237)	Charcoal	Pit in Unit H	
R_6	1410± 50 (SMU-327)	Wood	Base of unit G	1.0
R_5	1900± 80 (SMU-538)	Charcoal	Feat. 408, unit E_2	0.9
R_5	1990± 50 (SMU-234)	Charcoal	Top of Unit E	0.8
R_5	2040± 60 (SMU-537)	Charcoal	Feat. 392, Unit E	1.0
R_5	2250±100 (SMU-554)	Charcoal	Feat. 415, Unit E	1.0
R_5	2340± 80 (SMU-236)	Wood	Base of Strat. E.	1.4
R_4	2910± 50 (SMU-238)	Charcoal	Top of Strat. D	1.6
R_4	3050± 60 (SMU-235)	Charcoal	On top of Strat C_2	1.7
R_4	3330± 50 (SMU-331)	Charcoal	Feat. 3, Strat. D^2	1.5
R_4	3400± 60 (SMU-818)	Nuts	Deep trench, unit K_2	1.4
R_4	3650± 70 (SMU-550)	Charcoal	Feat. 424, Unit K_2	1.0
R_4	3800±180 (SMU-559)	Charcoal	Sedalia comp 3, unit K_2	0.9
R_4	3790± 60 (SMU-820)	Wood	Deep trench, unit K_2	1.6
R_4	3920± 70 (SMU-558)	Charcoal	Lower Sedalia, unit K_2	1.5
R_4	3940± 70 (SMU-419)	Charcoal	Sedalia comp 1, unit K_2	1.7
R_4	3930± 60 (SMU-319)	Charcoal	Sedalia comp 1, unit K_2	1.2
R_4	3960± 70 (SMU-556)	Charcoal	Sedalia comp 1, unit K_2	1.4
R_4	4000±100 (SMU-423)	Charcoal	Sedalia comp 1, unit K_2	1.9
R_4	4240± 80 (SMU-102)	Charcoal	Sedalia comp 1, unit K_2	1.7
R_4	4245± 60 (SMU-483)	Charcoal	Sedalia comp 1, unit K_2	1.4
R_4	4310± 70 (SMU-98)	Charcoal	Sedalia comp 1, unit K_2	1.7
R_3	4980± 70 (SMU-811)	Twigs	Deep trench, unit K_1	1.4
R_3	5390± 90 (SMU-539)	Moss	Pollen Profile 74-2 unit K_1	1.7
R_3	5370±120 (SMU-815)	Twigs	Deep trench, unit K_1	1.7
R_2	6460± 90 (SMU-810)	Twigs	Deep trench, unit C_3	1.5
R_2	6780±195 (SMU-505)	Charcoal	Unit C_2	2.0

R_2	6970±90 (SMU-819)	Moss	Deep trench, unit C_2	2.0
R_2	7090±90 (SMU-557)	Wood	Unit C_2	2.0
R_2	7240±100 (SMU-812)	Twigs	Deep trench, unit C_2	
R_2	7300±80 (SMU-726)	Wood	Monolith, unit C_2	3.3
R_2	7480±80 (SMU-193)	Moss	Unit C_2	
R_2	7620±90 (SMU-736)	Oak	Deep trench, unit C_2	3.0
R_2	7750±90 (SMU-735)	Sycamore	Deep trench, unit C_2	3.4
R_2	7870±90 (SMU-78)	Wood	1973 trench, unit C_2	3.6
R_2	7980±70 (SMU-727)	?	Monolith, unit C_2	
R_2	8050±90 (SMU-737)	Wood	Deep Trench, unit C_1	5.4
	8350±90 (SMU-518)	Water	Bicarbonations	
BS?	25,350±440 (SMU-813)	Humates	Monolith, unit A	5.7

Trench 76-D (opposite shelter)

P_2	190±40 (SMU-500)	Leaf mat	Upper Pippins alluvium	2.4
P_2	260±40 (SMU-432 & 508)	Wood	Upper Pippins alluvium	3.0
P_2	240±50 (SMU-499 & 485)	Leaf mat	Upper Pippins alluvium	3.0
R_5	1750±90 (SMU-430)	disp-charcoal	Rodgers alluvium	1.3
R_5	2360±70 (SMU-506)	disp charcoal	Rodgers alluvium	2.0
R_4	3560±90 (SMU-429)	Carcoal	Rodgers alluvium	2.0

Trench 77-E (Avery Bridge)

P_1	550±100 (UCR-822)	Charcoal	Pippins alluvium	0.8
P_1	730±100 (UCR-821)	Charcoal	Pippins alluvium	1.2
R_4	3470±130 (UCR-818)	Charcoal	Rodgers colluvium	0.8
R_4	3985±100 (UCR-819)	Charcoal	Rodgers alluvium	2.2
R_4	4585±130 (UCR-820)	Charcoal	Rodgers alluvium	2.4

Trench 77-A Buzzard's Bluff)

P_1	680±100 (UCR-823)	Charcoal	Lower Pippins alluvium	1.5
P_1	820±110 (UCR-824)	Charcoal	Lower Pippins alluvium	1.5
	750±100 average of above			

Trench 78-B (Giant Hickory)

R_4	3680±100 (SMU-823)	Charcoal	Rodgers alluvium	0.4
R_3	5110±280 (SMU-816	Charcoal	Rodgers alluvium	0.9
R_2	7990±120 (SMU-814)	Charcoal	Rodgers alluvium	2.7

Boney Spring

	Modern (Tx-1469)	Wood	Intrusive, fallen branch	?
R_5	1920± 50 (Tx-1472)	Wood	Prehistoric pit, unit I	1.3
R_5	1910± 80 (Tx-1470)	Humates	Outside of pit, unit I	1.1
R_5	1900± 80 (Tx-1471)	Wood	Outside of pit, unit I	1.3
R_4	4200±140 (A-1076)	Nuts	Base of unit I	1.6
R_2	7290±1,900 (Tx-1466)	Charcoal	Disperal in unit F	2.6
BS	13,550±400 (A-1079)	Peat	Tusk filling, unit E_2	3.1
BS	13,700±600 (M-2211)	Peat	Tusk filling, unit E_2	3.1
BS	16,190±400 (Tx-1629)	Moss	Unit E_1 tufa	4.0
BS	28,230±940 (Tx-1473)	$CaCO_3$	Unit E_1 tufa	4.0
BS	16,450±200 (1-4236)	Spruce	Unit E_2/E_1	3.6
BS	16,490±290 (Tx-1477)	Spruce	Unit E_2/E_1	3.6
BS	16,580±220 (1-3922)	Spruce	Basal unit E_2	3+
BS	16,540±170 (Tx-1478)	Spruce	Basal unit E_2	3+
BS	20,300±470 (Tx-1474)	Wood	Upper unit C_4	3.9
	17,320±1,810 (Tx-1475)	Humates	(Same sample)	
	19,550±1,080 (Tx-1476)	Humates	(Same sample)	
BS	21,380±500 (Tx-1410)	Wood	Lower Unit C_4	4.2
BS	20,710±530 (Tx-1479)	Wood	Lower unit C_4	4.9
BS	22,730±590 (Tx-1408)	Peat	Upper unit C_3	4.8
BS	28,330±3,140 (Tx-1407)	Humates	Upper unit C_3	4.8
BS	26,440±1,170 (Tx-1409)	Wood	Lower unit C_3	5.1
BS?	24,460±10,000 (Tx-1467)	Peat	Basal unit B_1	6.2
	27,480±1,950 (Tx-1468)	Humates	(Same sample)	

Trolinger Spring

BS	20,500±450 (1-3535)	Peat	Unit e	1.7
	17,250±600 (1-3536)	Humates	(Same sample)	
T_2	29,340±900 (A-1000)	Peat	Unit d_3	1.5
T_2	14,450±550 (Gx-1318)	Peat	Unit d_3	1.8
	4290±230 (Gx-1319)	Humates	(Same sample)	
T_2	33,220±1900-1600 (I-3599)	Peat	unit C	2.1
BS?	21,940±430 (SMU-170)	Collagen	Mastodon, unit d_3	
	20,100±480 (SMU-147)	apatite	(Same sample)	
	22,330±700 (SMU-148)	apatite	(Same sample)	
	420±120 (SMU-145)	Secondary CO_3	(Same sample)	
T_2	34,300±1200 (A-1080)	Peat	unit C (tusk filling)	
BS	25,650±700 (I-3537)	Straw	unit b	2.3

Koch Spring

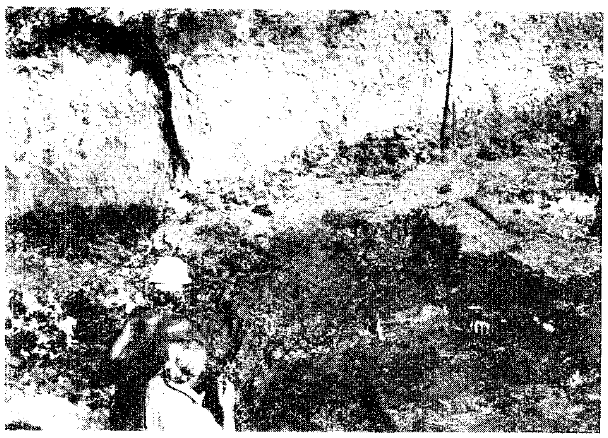
	143.9±5.7%M (Tx-1456)	Wood	intrusive, fallen branch	1.7
P_1	620±80 (Tx-1411)	Wood	Pippins terrace	1.1
P_1	640±60 (Tx-1453)	Wood	Pippins terrace	1.9
P_1	840±60 (Tx-1454)	Wood	Pippins terrace	2.3

K		31,880	1340	(Tx-1412)	Straw	Clayey, peat unit b_2	4.1
K		30,880	1320	(Tx-1455)	Humates	Clayey peat, unit b_2	4.5
K	>	38,000		(Tx-1457)	Wood	Brown clay, unit b_1	5.2
K		33,550	3210	(Tx-1458)	Humates	(Same sample)	
				Kirby Spring			
T_1		37,000		(Gx-2718)	Humates	Top of peat	1.2
T_1		27,000		(Gx-2719)	Humates	Bottom of peat	2.7
T_1		25,000		(Gx-2720)	Humates	Bottom of peat	2.7
				Jones Spring			
T_2		31,130	1550	(SMU-99)	Humates	Tusk filling	1.7
T_2	>	35,320		(SMU-94)	Peat	Upper unit e_2	1.8
		44,040	2660	(SMU-96)	Humates	(Same sample)	
T_2	>	40,000		(Tx-1627)	Peat	Top of lower peat (C_2)	3.2
T_2		39,020	2600	(Tx-1626)	Humates	Base of lower peat (C_1)	3.6
T_2	>	40,000		(Tx-1628)	Wood	Olive gray clay	3.8
T_2		48,900	900	(QL-962)	Wood	Olive gray clay	3.5

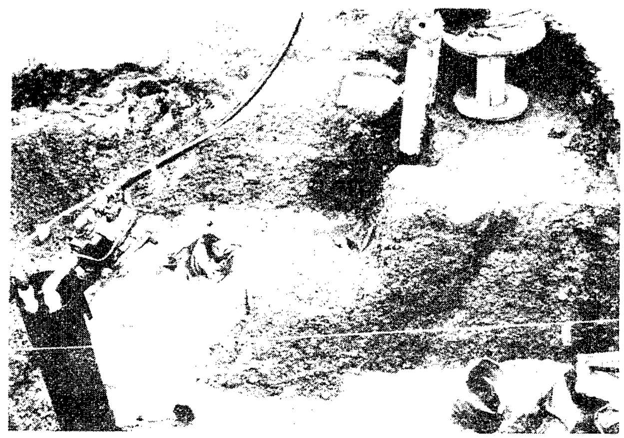
*Meters below terrace tread except for Rodgers Shelter and West terrace where it is depth below datum.

a

b



c



d

e

f

Figure 6. Views at springs.

related to abandonment of the meander. The overlying clays and sandy clays are vertical accretion deposits most of which may have been deposited by over-bank flooding into the abandoned meander. Gravel lenses become more frequent toward the colluvial slopes and apparently represent channels and alluvial fans from local discharge.

After abandonment of the Breshears meander and the T-2 terrace the Pomme de Terre incised its channel about 2 m deeper into bedrock before aggradation of Koch alluvium formed the next lower terrace, T-1a.

Koch alluvium

The 6.7 m terrace (T-1a) at Koch Spring (Fig. 4e) was originally considered to be an erosional remnant of T-2 (Trolinger alluvium) the deposits of which were informally called Koch alluvium (Haynes, 1976). The lower elevation of the terrace containing the Koch Spring deposits, compared to the host deposits for Jones and Kirby Springs, led to the suggestion that the Breshears Valley deposits might be high over-bank facies of Koch alluvium (Haynes, 1978). The T-2 deposits can, however, be interpreted as being older than the Koch deposits (T-1a), and Brakenridge (1979, 1981) has suggested a new name, Trolinger formation, for T-2 which is retained in the present report.

Radiocarbon dating does not as yet resolve the problem because the most reliable dates from Koch, Kirby and Jones Springs are at or beyond the limit of most radiocarbon detectors. An exception is the laboratory at the Quaternary Research Center at Seattle, Washington which can obtain finite ages up to 75,000 B.P. (Grootes, 1978). Sample Q-962 from Jones Spring is from this laboratory and other key samples being processed there from the Spring deposits will hopefully establish the ages that have eluded stratigraphic studies.

Koch alluvium as revealed by trenching at and adjacent to Koch Spring (Fig. 7, B-B^1) consists of olive gray (5Y 6/2, 5/2) clay and sandy clay interbedded

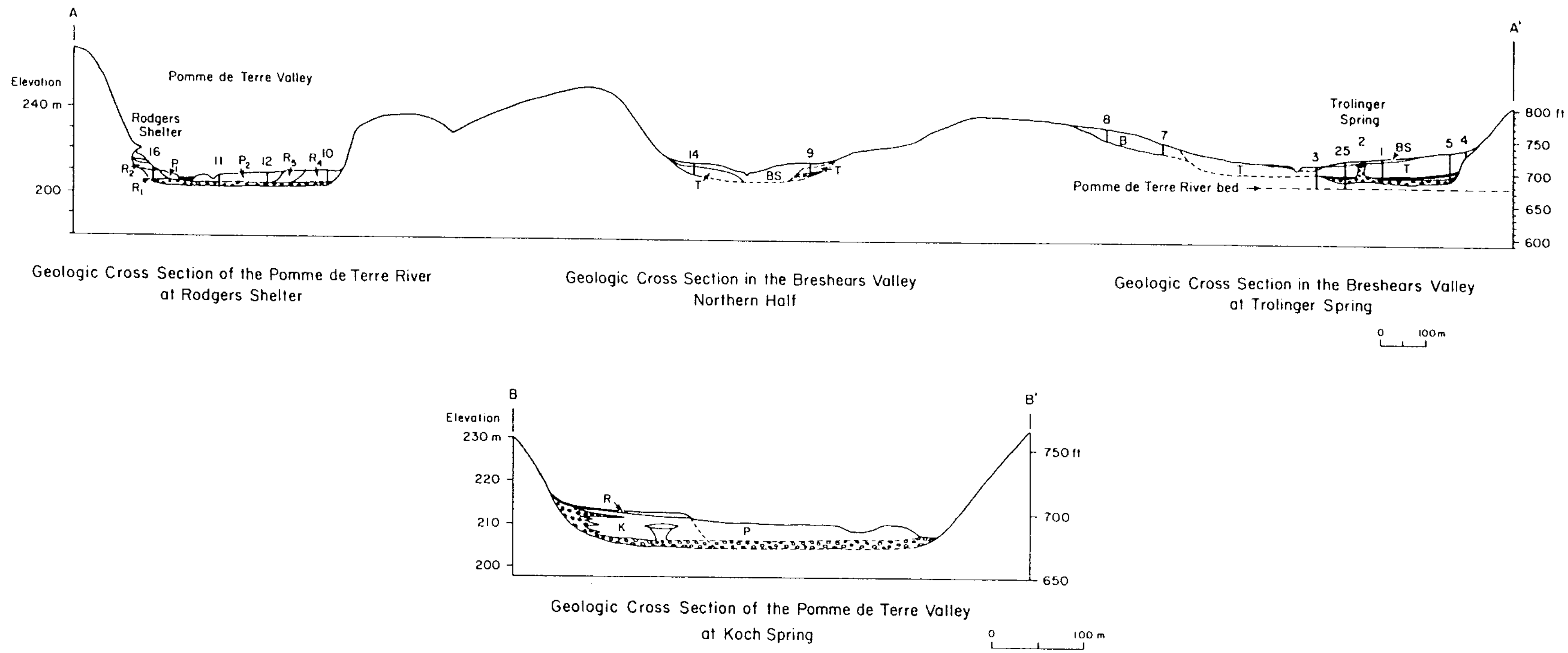


Figure 7. Geologic cross section (A-A^1) of the Pomme de Terre and Breshears valleys constructed from excavations and core sampling. Geologic cross section (B-B^1) of the Pomme de Terre Valley at Koch Spring.

with colluvial dolomite and angular chert gravel in the upper third and toward the dolomite hillslopes. Toward the surface the olive gray color is mottled with yellowish-brown color (10YR 5/6, 4/4) and is gradational over 10 cm to a dark, grayish-brown (10YR 4/4, 4/2), weakly prismatic soil best preserved in the footslope outcrops (Johnson, 1977). Wells drilled at Koch Spring prior to beginning our 1971 excavations encountered a meter or two of basal chert gravel over bedrock.

Most of the Koch terrace is covered with up to 50 cm of grayish-brown (10YR 5/2, 3/2) clayey silt that contains dispersed Archaic artifacts and is an over-bank facies of the Rodgers alluvium. The paleosol on the upslope part of the Koch alluvial terrace is truncated by the contact with the Rodgers over-bank deposit indicating that the terrace tread may have been lowered by perhaps as much as a meter by flood scour.

Radiocarbon dates for Koch alluvium obtained from the buried peat lens at Koch Spring indicate an age range from about 30,000 B.P. to more than 38,000 B.P. (Table 1). Pollen analyses reveal an open pine parkland during accumulation of most of the peat in the upper Koch formation, but a few spruce grains appear at the top of the profile (King, 1973; King and Lindsay, 1976). There may be a degree of temporal overlap between the peat at Koch Spring and that at Trolinger Spring. This will be evaluated later in the section on Trolinger Spring.

<u>Boney Spring alluvium</u>

An erosional hiatus of 4,000 to 6,000 years separates abandonment of the Koch terrace (T-1a) from the beginning of the Boney Spring terrace (T-1b) aggradation dated 26,440 ± 1170 B.P. (Tx - 1409) near the base of Boney Spring alluvium at Boney Spring, 3.2 km (2 mi) northwest of the Breshears Valley

(Fig. 9, F-F[1]). At Boney Spring (Fig. 6e) the alluvial deposits consist of 5 to 7 m of interbedded gray (5Y 7/1, 5/1) to olive (5Y 5/3, 4/1) organic clays, clayey silts and peat over 1 to 3 m of chert pebble gravel. They are intruded by spring-laid granular tufa and clay containing spruce logs and bones of mastodon, giant beaver, ground sloth and smaller animals (Saunders, 1977a).

Boney Spring alluvium was encountered in the T-1 terrace complex 5 to 6 m above streambed in two trenches upstream from Boney Spring. In one case (Trench 77B) it was overlain by a colluvial facies (Brakenridge, 1979, 1981), in the other (Breshears Valley), Boney Spring alluvium interbedded with colluvial gravel and slope wash against the dolomite hillsides (Fig. 5). Exposures along Spring Branch and at Trolinger Spring reveal an erosional contact with the Trolinger formation, and a well developed dark gray soil (Johnson and others, 1980) at the top of the formation around Trolinger Spring is probably a continuation of that on the Trolinger formation.

The pollen evidence indicates initial aggradation under open pine parkland conditions changing to a spruce dominated forest around 20,000 B.P. that lasted until 16,500 B.P. after which the bone deposit formed (King, 1973; Saunders, 1977a). At Boney Spring a hiatus of unknown duration occurs between the top of the clay (unit D) containing the spruce-dominated pollen record and the clay matrix (unit E) of the bone bed (Fig. 20), but remnants of an organic clay preserved in the nerve canal of mastodon tusks in unit E revealed that a mixed forest of spruce with deciduous trees existed at the spring 13,500 B.P. A hiatus therefore occurs between this date and 16,500 B.P. and indicates a period of non-deposition and most likely a significant reduction in spring discharge. The implied drought may have caused the death of several species of Pleistocene mammals (Saunders, 1977a).

Another hiatus in the Boney Spring sequence occurs sometime between 13,000 P.B. and 7,000 B.P. which can be narrowed down further on the basis of radiocarbon dates as old as 10,500 B.P. from the base of Rodgers alluvium (T-1c) at Rodgers Shelter. Therefore, abandonment of Boney Spring terrace and extinction of the Pleistoncene megafauna occurred between ca. 13,000 and 11,000 B.P.

Rodgers alluvium

Excavation of Rodgers Shelter from 1963 to 1968 (McMillan, 1971, 1976 e) and again in 1974 and 1976 (Kay, 1980) resulted in exposure of over 9 m of alluvium and colluvium forming the younger part of the intermediate terrace (T-1c) (Figure 8, D-D[1]). Four strata were defined on the basis of erosional and/or lithologic contacts (Ahler, 1976) with the lowest (Stratum 1) containing Paleoindian and early Archaic artifacts dating between 10,500 and 8,000 B.P. in a matrix of strong brown (7.5 YR 5/6, 4/4) to dark grayish brown (10 YR 4/2, 2/2) alluvial clayey silt and colluvial gravel. Stratum 2 contains Middle Archaic artifacts and radiocarbon dates between 8,000 and 6,300 B.P. in a matrix of dark grayish brown (10 YR 4/2, 2/2) clayey silt. An erosional contact at its base truncates a dark brown (7.5 YR 4/4, 3/2) soil at the top of Stratum 1. A dark grayish brown (10 Y 3/2, 2/2) soil its top is conformably overlain by colluvial, mostly chert, gravel of Stratum 3 dating between 6,300 and 5,200 B.P. Stratum 4 is a mixture of alluvial silt and colluvial gravel, contains Late Archaic to Woodland artifacts, is divided into four subunits, and is dated at 3,600 to 1,500 B.P.

Environments of deposition and climatic inferences have been made from quantitative studies of the shelter and "west terrace" strata by Ahler (1973 and 1976) and Kay (1980) and will be discussed in conjunction with data from other sections of Rodgers alluvium.

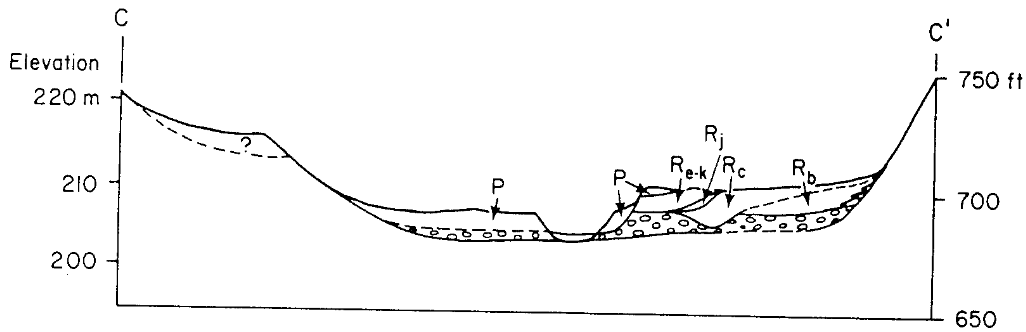
Subsequent mapping and trenching of Rodgers alluvium in the lower Pomme de Terre Valley has defined six episodes (R_1 through R_6) of cutting and filling (Fig. 3) that closely correspond to the depositional sequence in the shelter, except that a meter or so of chert gravel bedload occurs at the base of core holes carried to bedrock (Haynes, 1976, 1977). The earliest alluvium (T-$1c_1$) is best represented at the shelter and the extension of the terrace to the west (Kay, 1980) by Stratum 1 which is subdivided by Ahler (1973) into 6 sub-units. At the base is nearly 2 m of gray clayey, sandy silt (A^1) with a few dispersed clasts of stream-rounded chert gravel over bedrock dolomite. Northward toward the bluff this fine-grained alluvial sediment interfingers with a colluvial facies (A^2) of pebble- to large boulder-size fragments of dolomite obviously derived by mass wasting of the adjacent bluff. One meter of brown clayey silt (B^2) conformably overlies unit (A^1) with an abrupt but gradational contact that is essentially a color change between reducing conditions in zones of saturation below and oxidation above.

Toward the bluff unit (B^2) interfingers with colluvium (B^1), that is the same as below but somewhat finer, with numerous tabular fragments of dolomite arranged paralles to the buried talus slope. This is conformably overlain by 2.4 m of brown calyey silt of unit C which is essentially a continuation of alluvial aggradation begun with unit A deposition, except that it was deposited over talus of unit B^1 and contains thin lenses of subrounded to angular chert. Unit D, up to 1.8 m thick, is likewise a continuation of Unit C aggradation but with clear evidence of pedogenesis in the form of darker color, moderate soil structure, root molds, and clay skins in a zone up to 30 cm thick. Much of this paleosol is truncated by the contact with overlying Stratum 2, which itself is up to 1.4 m of dark grayish brown clayey silt with dispersed pebbles, cobbles, and a few boulders of colluvial dolomite that are less tabular and unoriented as compared to the colluvium

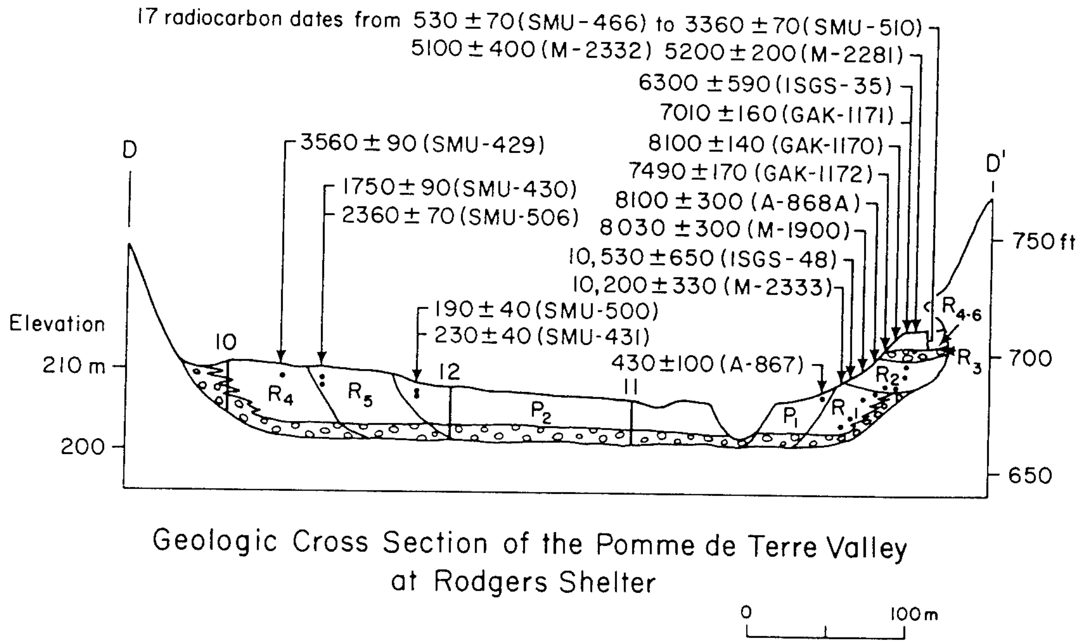
of unit B^1. Pedogenic development in Stratum 2 is stronger than that in unit D.

Radiocarbon dates from Stratum 1 (Table 1) indicate that approximately 4.6 m of alluvial silt were deposited between 10,350 and 8,100 B.P. or 0.20 cm/yr (Table 2). Then 1.9 m of Stratum 2 were laid down between 8,000 and 6,300 B.P. at a rate of 0.11 cm/yr. The radiocarbon dates leave no time for the hiatus clearly indicated by soil development followed by erosion between Stratum 2 and the top of Stratum 1. During this time the river degraded to at least 2.8 m of the present streambed. This is indicated by a radiocarbon date of 8,050 ± 90 B.P. (SMU-737) on wood from a buried channel 5 m below the surface of the Rodgers terrace (T-1c) at Phillips Springs (Figs. 8, $C\text{-}C^1$ and 10), an archaeological site on the river about 4 km southwest of the shelter. Subsequent work on the buried archaeological horizons there (Chomko, 1976; Kay, 1980) reveal that this, the second aggradational stage of Rodgers alluvium, consists of clayey silt and clay which correlates with Stratum 2 at the shelter where the youngest date is 6,300 ± 590 (ISGS - 35) at the top. At both Phillips Spring and Rodgers Shelter radiocarbon dates bracket an erosional hiatus between this 6,300 date at the shelter and a date of 5,370 ± 120 (SMU 815) from the middle of unit J at Phillips (Fig. 10). Considering the shelter, the hiatus corresponds to the interval between the top of Stratum 2 and the base of Stratum 3. Dates from aboriginal pits dug into the alluvial fan gravels of Stratum 3 and from unit J at Phillips Spring indicate that a short episode of aggradation occurred between 5,400 and 5,000 years ago. Sometime between 6,000 and 5,400 years ago the river had degraded to at least 1.7 m below the top of the Rodgers Terrace (T-1c). It is not known if it had cut all the way to bedrock.

In 1976 a backhoe trench (76-D) was excavated through the terraces across the river from Rodgers Shelter in order to have a more complete picture of the

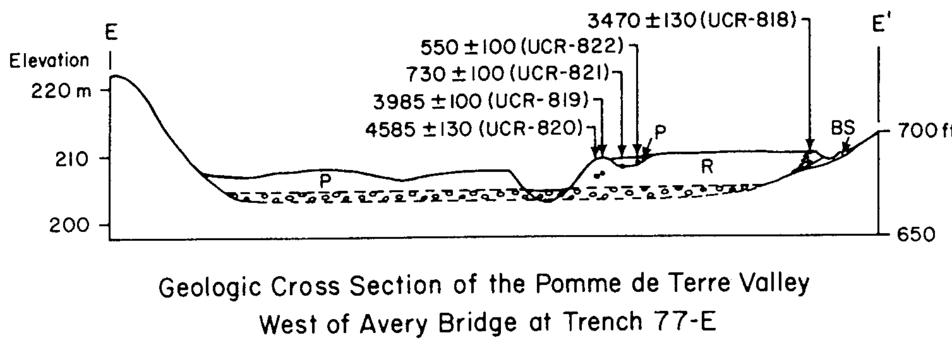


Geologic Cross Section of the Pomme de Terre Valley at Phillips Spring



Geologic Cross Section of the Pomme de Terre Valley at Rodgers Shelter

Figure 8. Geologic cross sections of the Pomme de Terre Valley; C-C[1] Phillips Spring; D-D[1] Rodgers Shelter and Trench 76D.



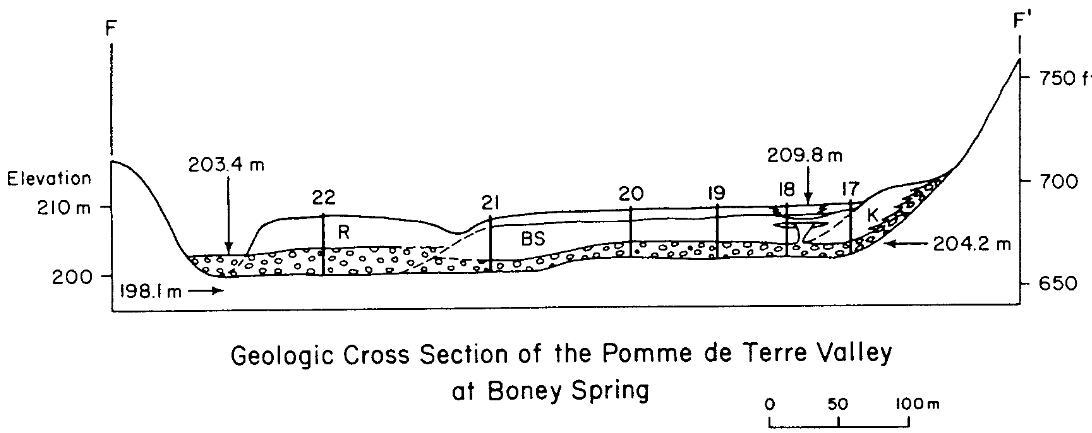


Figure 9. Geologic cross sections of the Pomme de Terre Valley; E-E[1] Trench 77E west of Avery Bridge; F-F[1] Boney Spring.

alluvial sequence. This revealed two late cut-and-fill stages of Rodgers alluvium (Fig. 8, D-D[1], R^4 and R^5) to consist of light-brown (10YR 5/3, 3/3) clayey silt much like Stratum 1. Charcoal 2 m below the tops of each alluvial fill dated 3,560 ± 90 B.P. (SMU-429) and 2,360 ± 70 B.P. (SMU-430). The erosional contact between them was so faint that it was recognized only after proper scraping of the trench wall, (Fig. 11) but it correlates with a stratigraphic break in the lower part of Stratum 4 (unit G_1) at the shelter (Kay, 1980, pp. 82, 99-104).

Between about 0.5 and 2 m depth at the Phillips Spring site, 21 radiocarbon dates were obtained within the 1.5 m vertical interval (Fig. 10) and range from 4,310 ± 70 B.P. (SMU-98)to 1,900 ± 80 B.P. (SMU-538). Most, but not all, of the dates are consistent with depth, but micro-stratigraphic relationships have been difficult to correlate from one season's excavation to another (Chomko, 1978; Haynes, 1978; Kay, 1979) the reason being that the most intensive human occupation occurred during this interval between 5,000 and 1,900 years ago (Kay, 1980). The cultural disturbance is such that it would be surprising not to have some anomalies in the sequence. The situation also exemplifies the problems of trying to sort out stratigraphy with radiocarbon dates instead of the reverse, but in this case we have no choice.

A deep backhoe trench (Fig. 12) made in 1978 substantiated the stratigraphic model proposed after the previous season (Haynes 1977) and confirmed the regional occurrence of several stratigraphic breaks seen at Rodgers Shelter and in several stratigraphic trenches. The maximum deposition rate for Rodgers alluvium of 0.63 cm/yr. occurred between 8,050 and 7,750 B.P. in the lower part of the channel fill exposed by the deep trench. The lowest rate, 0.05 cm/yr., occurred in Rodgers Shelter, Stratum 4 which has a significant colluvial component. The mean rate is 0.19 cm/yr. (Table 2).

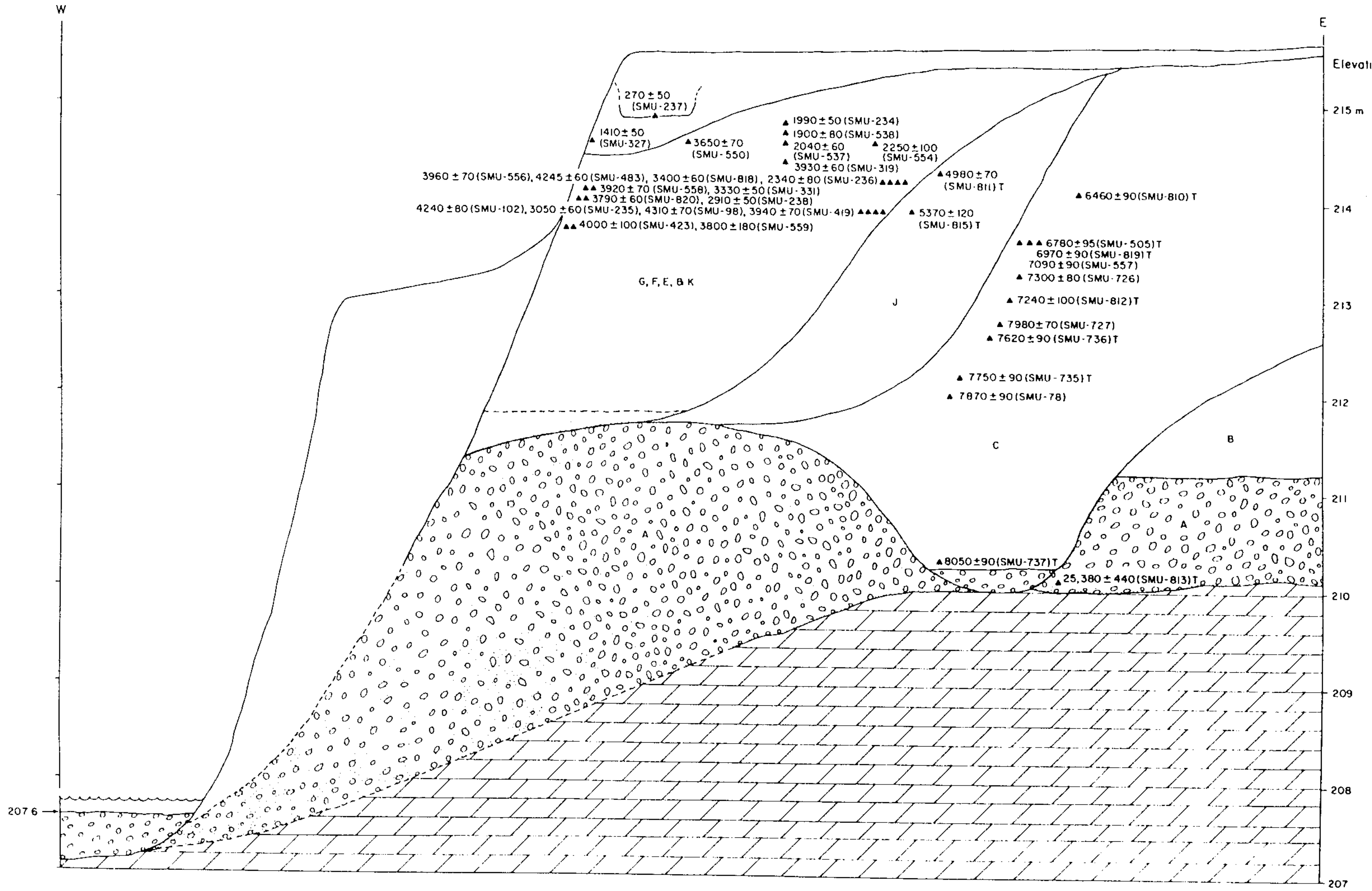


Figure 10. Generalized chronostratigraphic cross section at Phillips Spring showing the position of radiocarbon samples.

Not clarified is the maximum depth of downcutting by the river during the erosional intervals following deposition of unit C about 6,000 years ago (Figs. 11 & 12), but some of the erosional breaks seen in the archaeological stratigraphy are probably local scour events produced by overbank floods. Deeper channel facies, therefore, need not be expected for every break. In fact it is entirely possible that after 6,300 B.P. the river did not cut to the depths of the basal gravels during Rodgers time because no younger dates have been found more than 2.5 m below the top of the Rodgers terrace. On the other hand trenches did not reveal the lower limits of these younger Rodgers fills (R_3 - R_6), and considering the measured rates of deposition for the older Rodgers fills (R_1 & R_2) it is quite possible that the erosional hiatuses are on the order of 100 years or so.

A stratigraphic backhoe trench (77-E) (Fig. 9, E-E^1) downstream from Rodgers Shelter about 1.2 km (west of the site of Avery Bridge) exposed several archaeological horizons between 1.5 and 2.5 below the Rodgers terrace (T-1c). Two radiocarbon dates 2.2 and 2.4 m below the surface dated 3,985 ± 100 B.P. (UCR-819) and 4,585 ± 130 B.P. (UCR-820) respectively and were overlain by a Late Archaic projectile point (Smith type). The stratigraphic position of the dates is compatible with the data from Phillips Spring and Trench 76-D.

In Trench 78B 300 m south of Koch Spring, stratigraphically consistent dates of 3,680 ± 100 B.P. (SMU-823) and 5,110 ± 280 B.P. (SMU-816) occur above a date of 7,990 ± 120 B.P. (SMU-814). No erosional contact was observed between the latter two (Brakenridge, 1979) but, as just discussed, the evidence for an erosional episode between about 6,000 and 5,500 B.P. is clear elsewhere. Another Smith point was found slightly below the youngest date which is consistent with the one from trench 77-E.

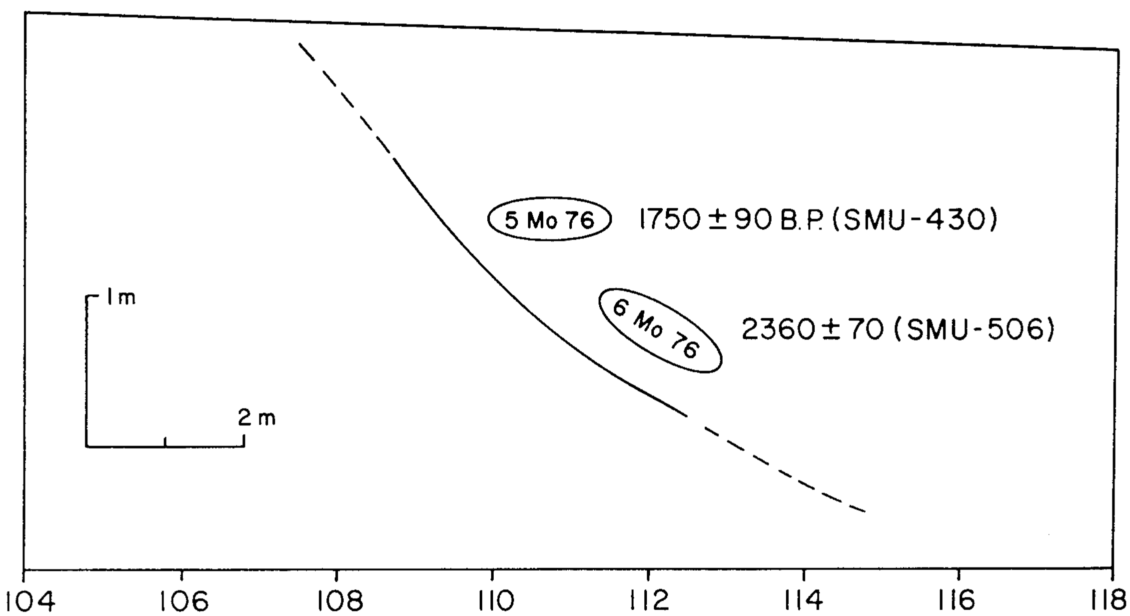


Figure 11. Section of Trench 76D showing relationship of radiocarbon samples 5Mo76 and 6Mo76.

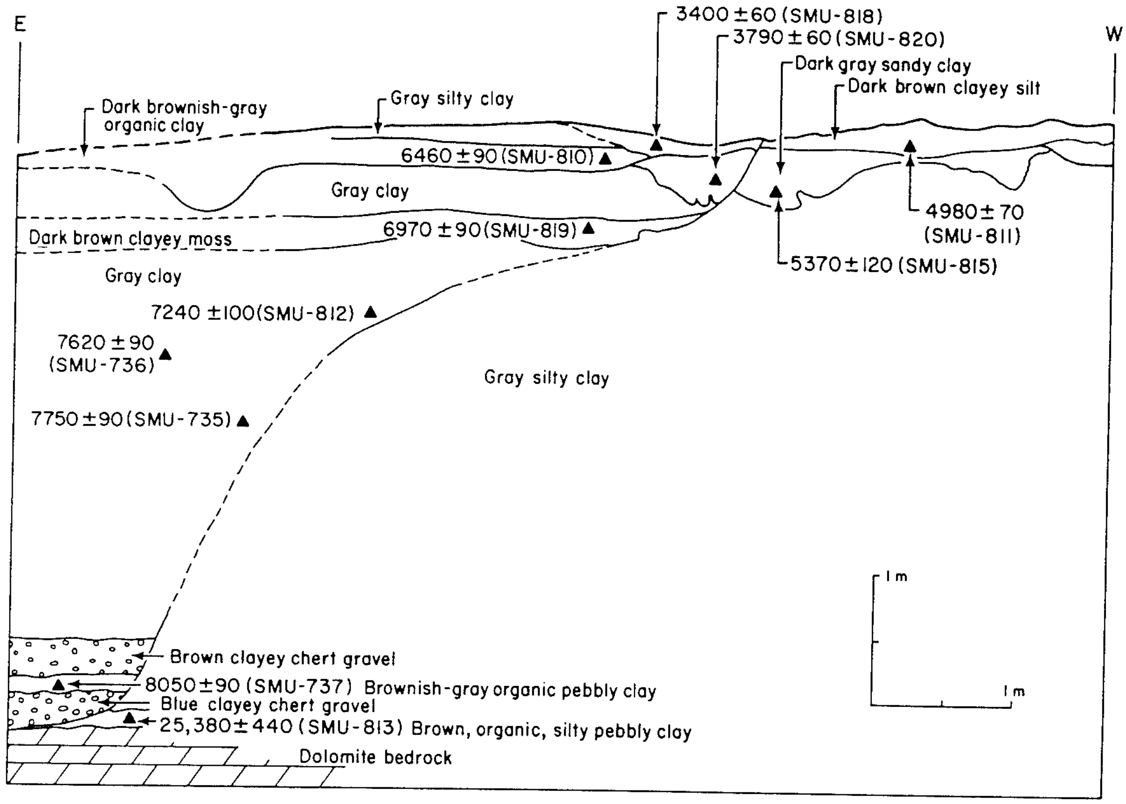


Figure 12. Stratigraphy of a deep backhoe exposure at Phillips Spring showing relationships of 10 radiocarbon samples.

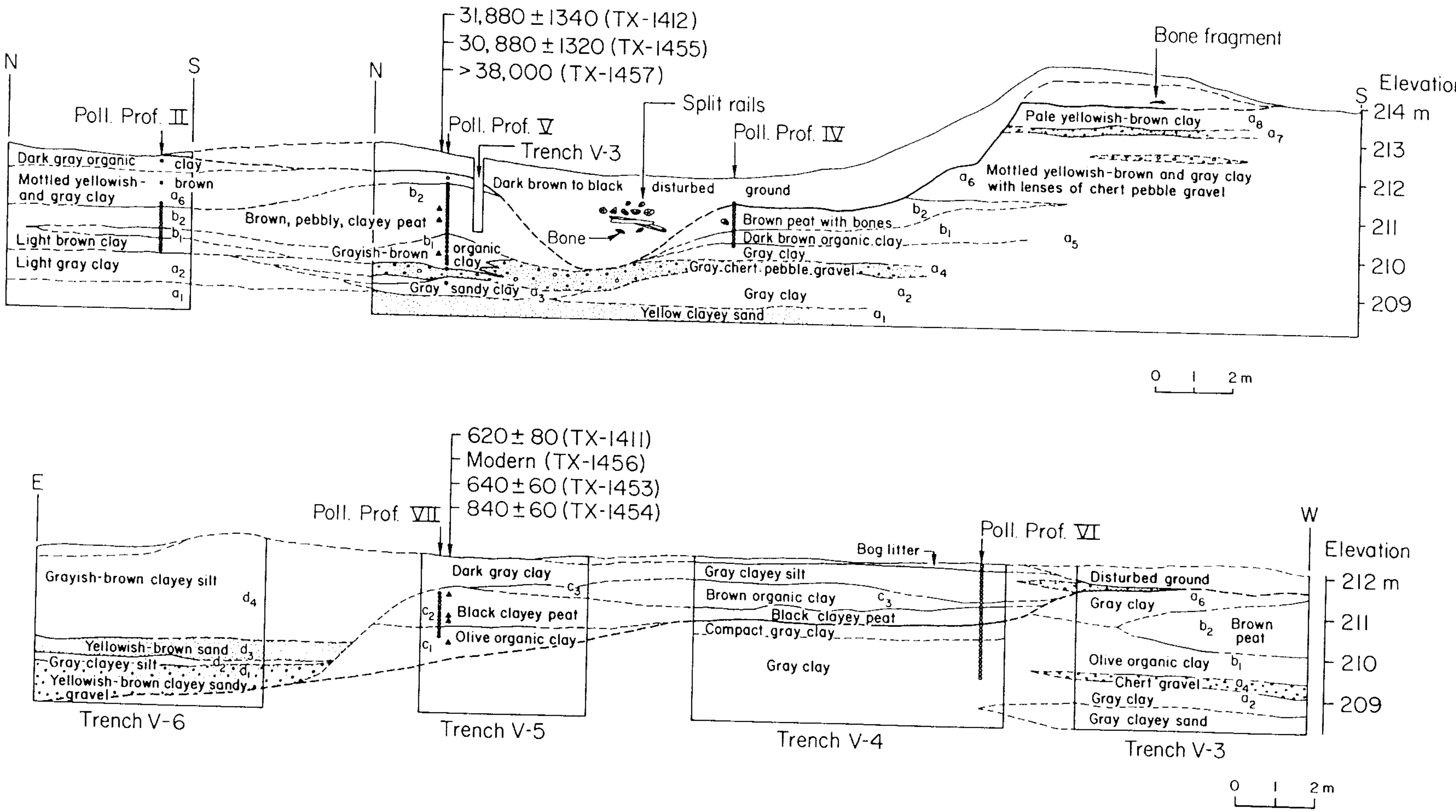
From the cross section of the Pomme de Terre Valley in trench 76-D and at Rodgers Shelter (Fig. 8, D-D^1), it is clear that the river did not aggrade to the level of Stratum 4 which stands 1 to 2 m above the top of the Rodgers compound terrace tread unless this surface has been reduced by scour. The flatness of the surface and its uniform soil do not suggest this, so what alluvial component Stratum 4 may have was most likely derived from relatively high, and probably infrequent floods, the rest possibly being due to slope wash resulting in a slow deposition rate of only 0.05 cm/yr. (Table 2).

Abandonment of the Rodgers terrace (T-1c) occurred after 1,600 B.P. according to the date from trench 76-D but may have been after 1,400 B.P. from the evidence at Philips Spring where fine-grained alluvium of this age (unit G) occurs near the top of the sequence (Fig.10). Next to the bluffs a black soil (Mollic Udiffuvent: Johnson, 1977) occurs at the top of colluvial facies of Rodgers alluvium.

Pippins alluvium*

The historic flood plain (T-0) (Fig. 4d) of the Pomme de Terre is also a compound, 4 to 6 m terrace of two cut-and-fill deposits each composed of gray silt or silty, fine sand over brown to gray sand over brown chert pebble gravel. Buried slough deposits containing well-preserved wood and leaves occur in both deposits and have provided several radiocarbon dates (Table 1). The oldest radiocarbon date of 840 ± 60 B.P. (Tx-1434) is in early Pippins alluvium (T-0a) exposed by a backhoe trench at Koch Spring (Fig. 13), and the youngest is 430 ± 100 B.P. (A-867) on charcoal 50 cm below the top where exposed by a bulldozer trench at Rodgers Shelter (Fig. 8, D-D^1). On the basis of similar evidence from

*The name is spelled Pippens on the Fristoe 15-minute quadrangle map (U.S.G.S. 1942), but the family spells their name Pippins.



GEOLOGIC CROSS SECTIONS OF KOCH SPRING, MISSOURI
1971

Figure 13. Stratigraphic profiles of trenches at Koch Spring.

trench 76D, late Pippins alluvium (T-0b) began to aggrade shortly before 300 yr B.P. and was still an active flood plain until completion of the dam at Lake Pomme de Terre in 1960 prohibited further flooding. Overbank deposition occurred on T-1c as late as 270 years ago at both Phillips Spring and Rodgers West Terrace and local residents report all of T-1 had been under several feet of water on August 8, 1927 during the highest flood of living memory. At the time the Breshears moved into the valley T-0b was probably much as it is today.

GEOCHRONOLOGY OF SPRINGS

Five fossil bone-bearing artesian springs occurring in the lower Pomme de Terre Valley form a rough NNW alignment (Fig. 2) and are characterized by peat lenses over sand feeders surrounded by chert gravels penetrating late Pleistocene alluvium. Our investigations from 1967 to 1979 greatly expanded knowledge of the age and anatomy of concentric-feeder or "eye" type springs in general and of associated flora and fauna of the Pomme de Terre area in particular.

Koch Spring, the most southerly, produced part of the collection of mastodon bones that Albert Koch sold to the British Museum in 1844. To the northwest 2.7 km in the southern arm of the Breshears Valley (Fig. 1), lies Kirby Spring where additional mastodon bones were uncovered during the latter half of the 19th century (McMillan, 1976a). Trolinger and Jones Springs lie less than a kilometer east of Kirby (Fig. 2), but fossil bones were not discovered in them until our test excavations of 1968 and 1971 respectively.

A spring 5 km northwest of Trolinger is known locally as Boney Spring because of the large bones that appeared at the surface on several occasions according to local verbal history. Fossil ivory was identified from a core sample for pollen analysis in 1965 (Mehringer and others, 1968) and bones of 31 mastodons were recovered in subsequent excavations (Saunders 1977a) at Boney Springs. A more prominent spring on the west side of the Pomme de Terre River 3 km north northwest of Boney Spring was the site of a resort in the mid 1900's known as Nigger Springs Camp. All of these springs lie on a northwesterly alignment so the possibility of a related fault is real though not proved.

Trolinger Spring

Before scientific excavations began in 1967, Trolinger was simply a wet, grass covered, shallow depression near the east bank of Jones Branch which

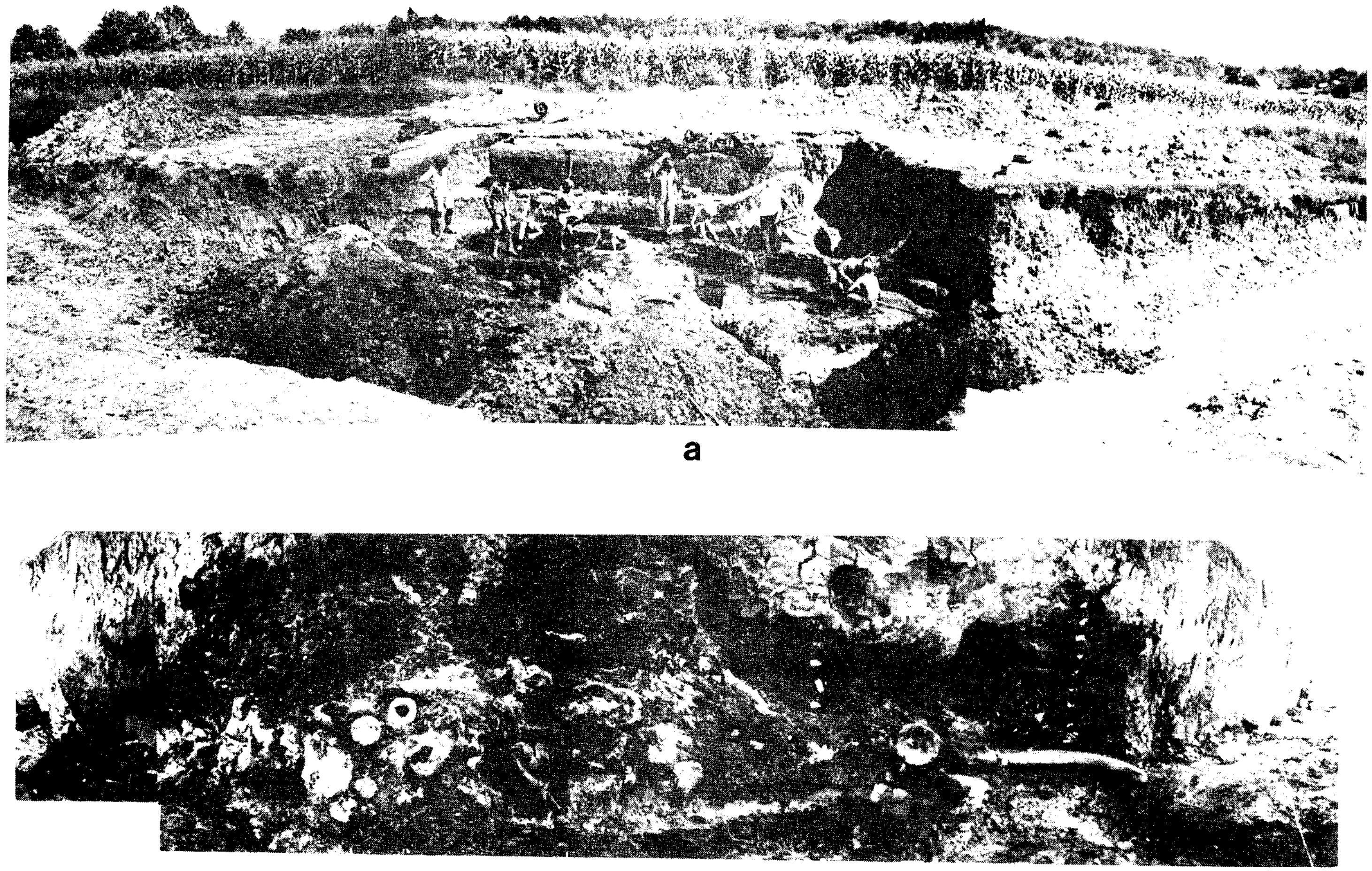
received a weak seepy discharge from the spring until 1964. According to Ivan Trolinger, the former owner, it ceased to flow two days after the Alaskan earthquake of March 27, which may account for some disturbed stratigraphy. Verbal history also recorded that at one time, a tractor became stuck in the spring.

Our excavations proceeded from a north-south bulldozer trench placed along the west side of the spring that provided both drainage and an initial look at the stratigraphy (Fig. 14a). Most of the fossil bones (Fig. 14b) occurred at the base of a lens of dark brown sandy peat (unit d_3) dating between 34,330 ± 1,200 B.P. (A-1080A) and 29,340 ± 900 B.P. (A-1000). They were disconformably overlain by a dark brown clayey peat (unit e) with a date of 20,500 ± 450 B.P. (I-3535).

A mixed layer (unit c) of peat, striped with lenses of white feeder sand (Fig. 15a), occurred between the peat and underlying white sand feeder (unit b). All of these springlaid deposits are overlain by gray silty clay of the Boney Spring alluvium.

In 1978 and 1979 renewed excavations were conducted at Trolinger to taphonomically recover the rest of the bones and to clarify the stratigraphic relationship of the spring deposits to the alluvium. From the results (Fig. 16) it is apparent that the compound peat lens rests on an erosional unconformity separating Trolinger alluvium from Boney Springs alluvium. The sand feeder (Fig. 6d) is surrounded by sandy, angular, blue chert gravel (Fig. 15b) that has intruded Trolinger alluvium either by stoping or injection along a line of weakness. At the final day of excavation deep backhoe trenches were made below the level of hand excavation and revealed the configuration of the gravel column as rising from the basal gravels underlying the Trolinger formation (Fig. 18).

Dispersed within the gravel column were pieces of wood, fragments of cellular tufa, and small masses of moss. These could have been brought up from the dark



a

b

Figure 14. Panoramic views at Trolinger Spring.

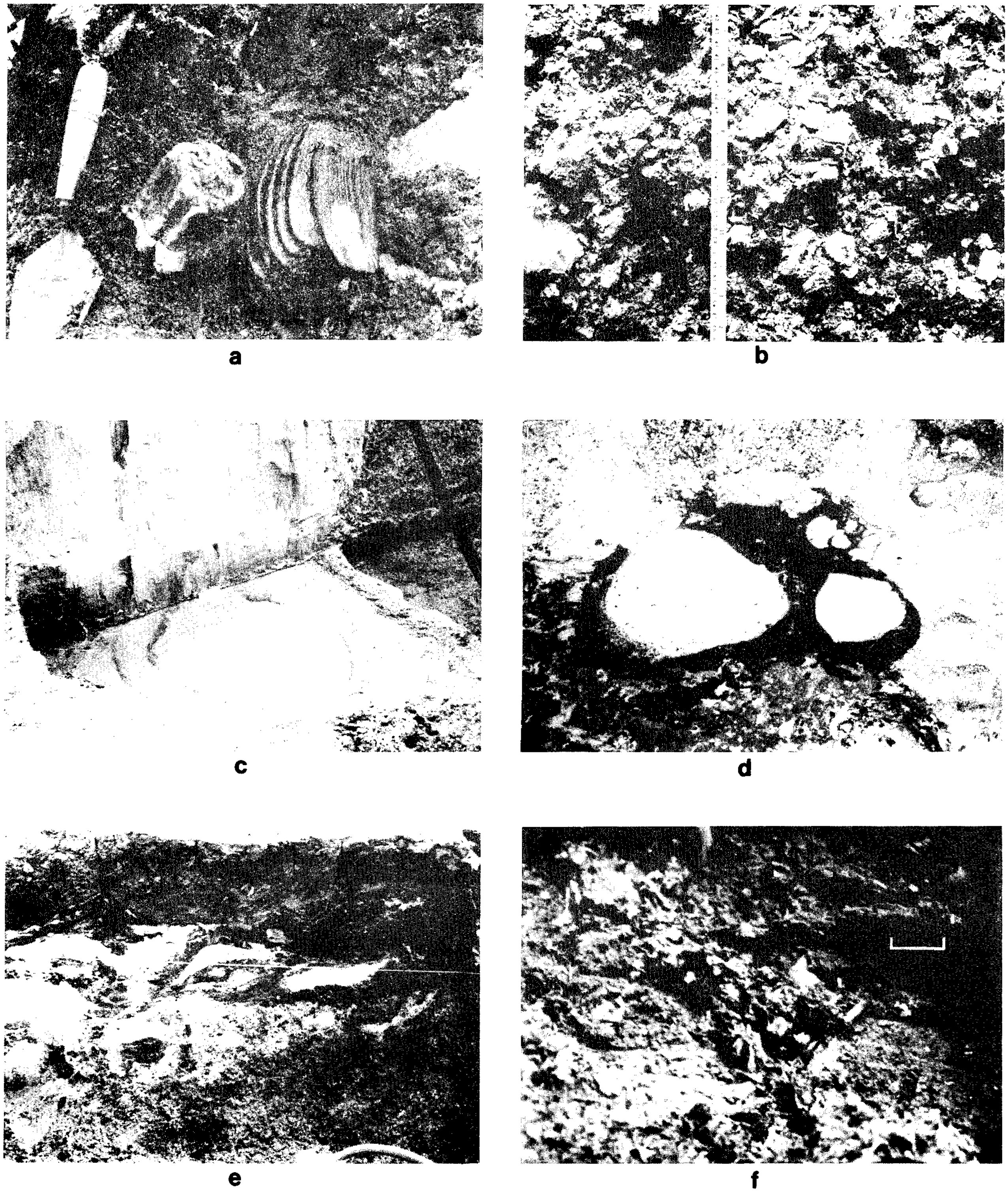


Figure 15. Views of spring sediments.

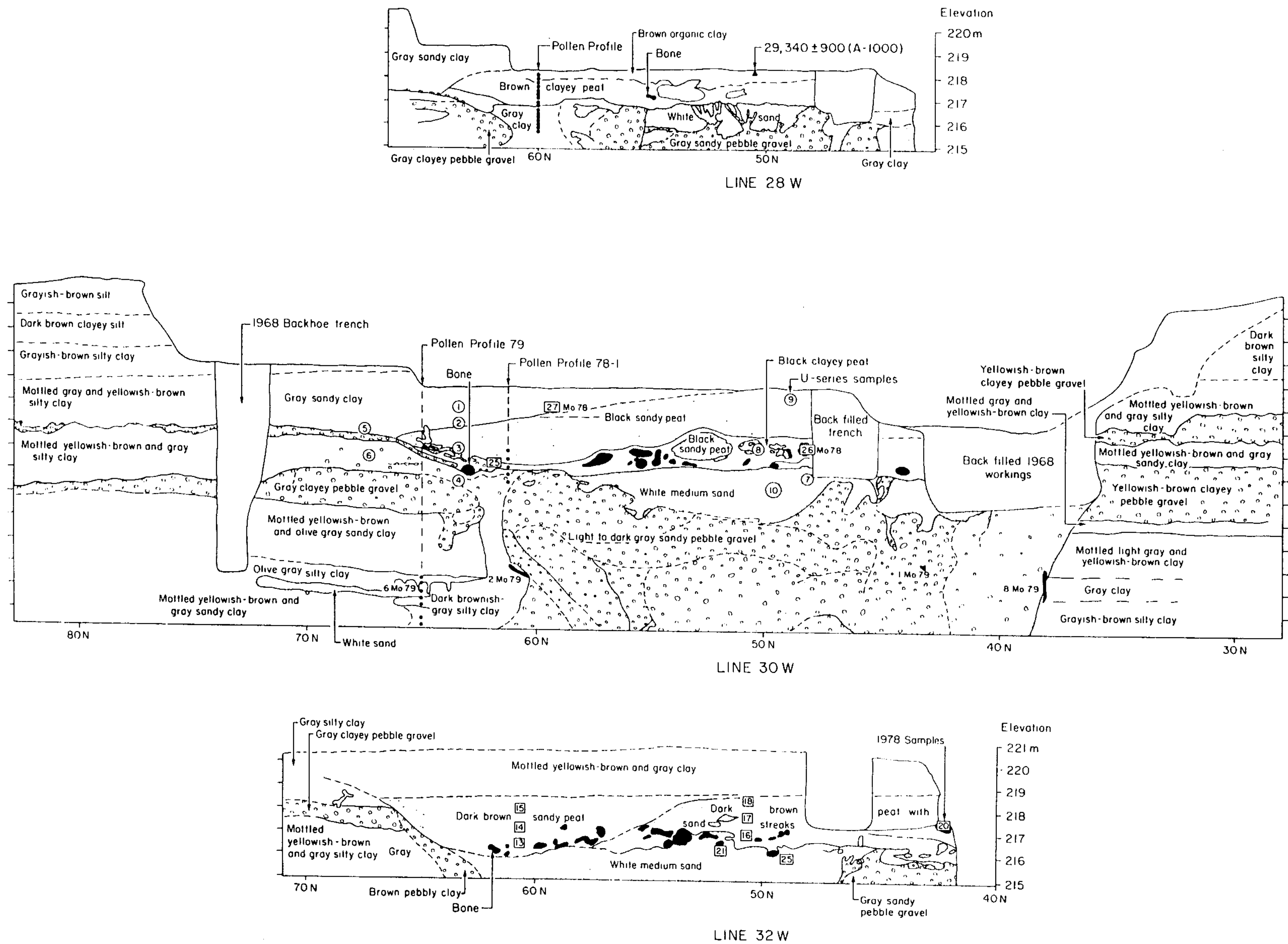


Figure 16a, b, and c. Stratigraphic sections through Trolinger Spring.

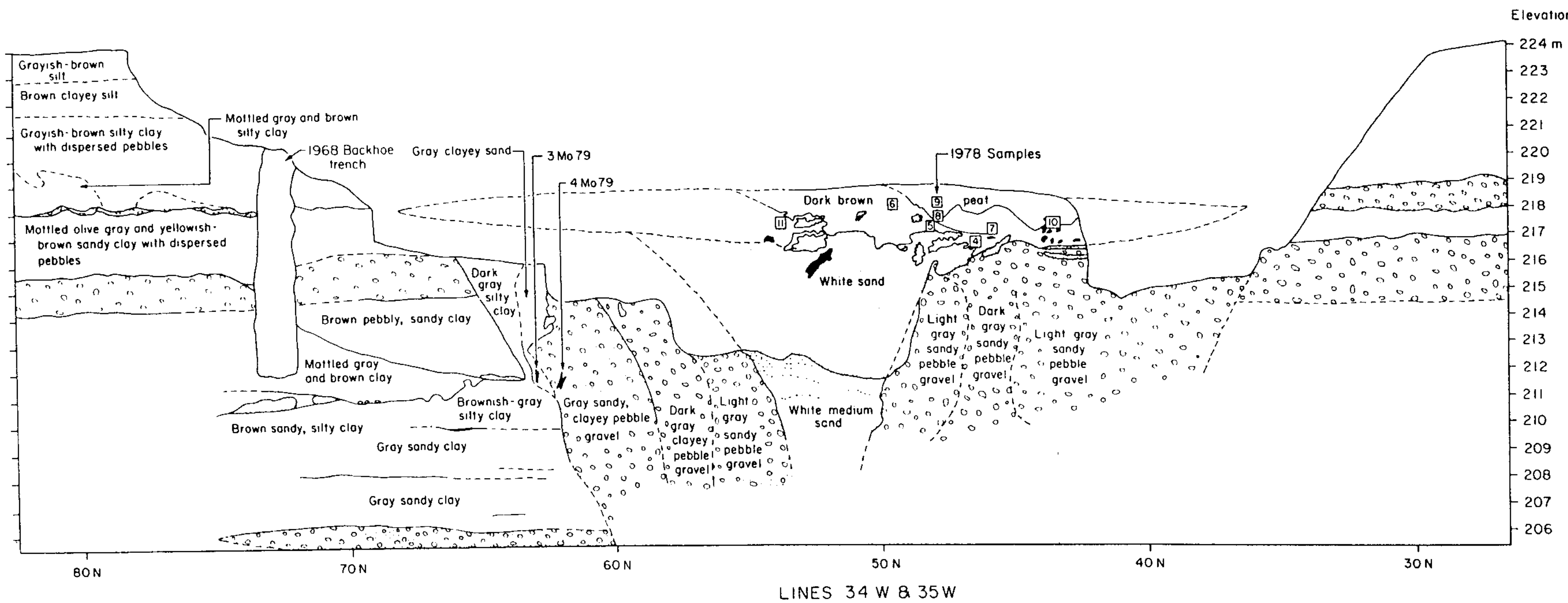
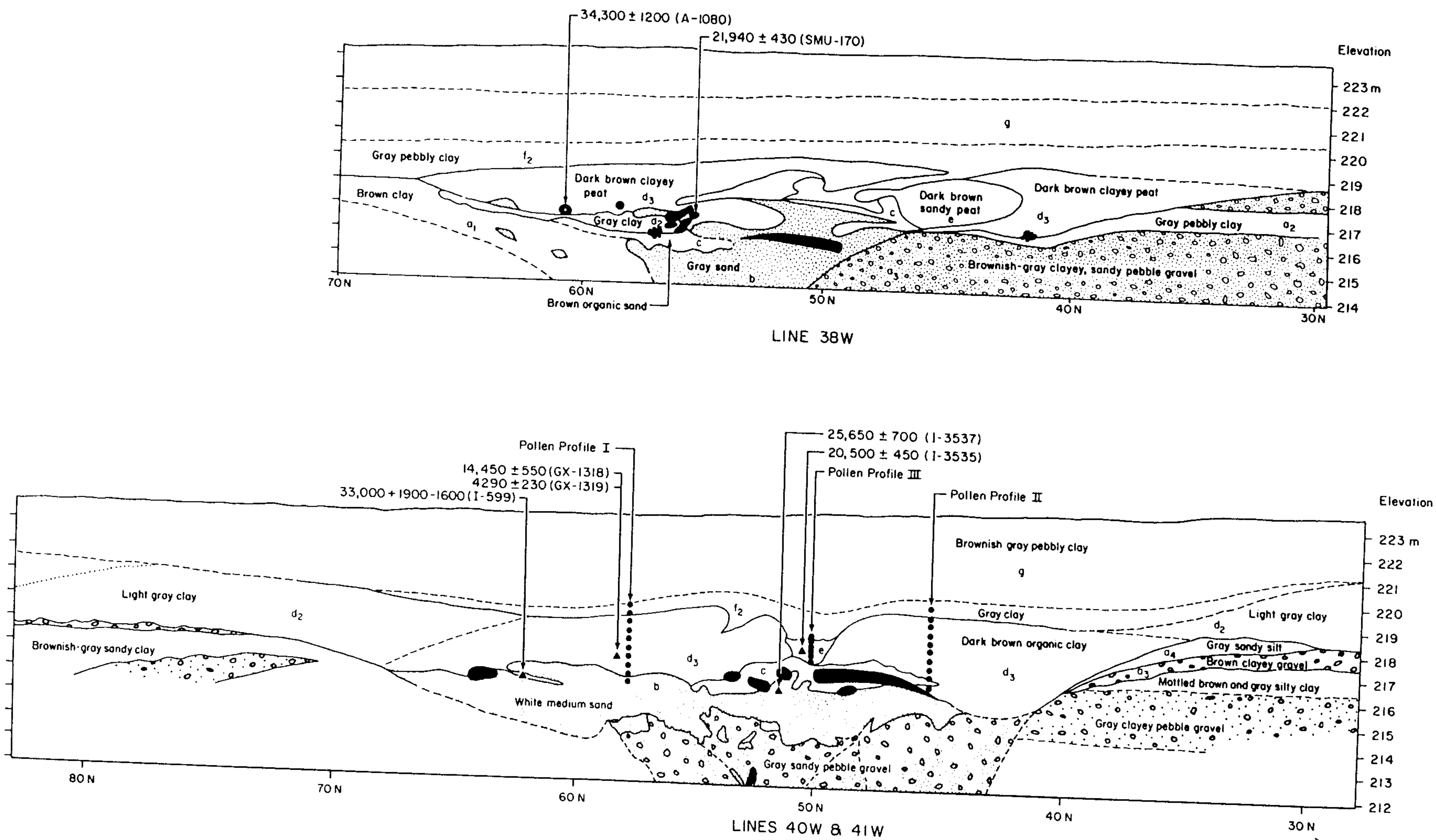

Elevation
224 m
223
222
221
220
219
218
217
216
215
214
213
212
211
210
209
208
207
206
Grayish-brown silt
Brown clayey silt
Grayish-brown silty clay with dispersed pebbles
Mottled gray and brown silty clay
1968 Backhoe trench
Gray clayey sand
3Mo79
4Mo79
1978 Samples
Dark brown
peat
White sand
Mottled olive gray and yellowish-brown sandy clay with dispersed pebbles
Dark gray silty clay
Brown pebbly, sandy clay
Mottled gray and brown clay
Brownish-gray silty clay
Brown sandy, silty clay
Gray sandy clay
Gray sandy clay
Gray sandy, clayey pebble gravel
Dark gray clayey pebble gravel
Light gray sandy pebble gravel
White medium sand
Light gray sandy pebble gravel
Dark gray sandy pebble gravel
Light gray sandy pebble gravel
80 N
70 N
60 N
50 N
40 N
30 N
LINES 34 W & 35 W

Figure 16b.



TROLINGER SPRING CROSS SECTIONS

Figure 16c.

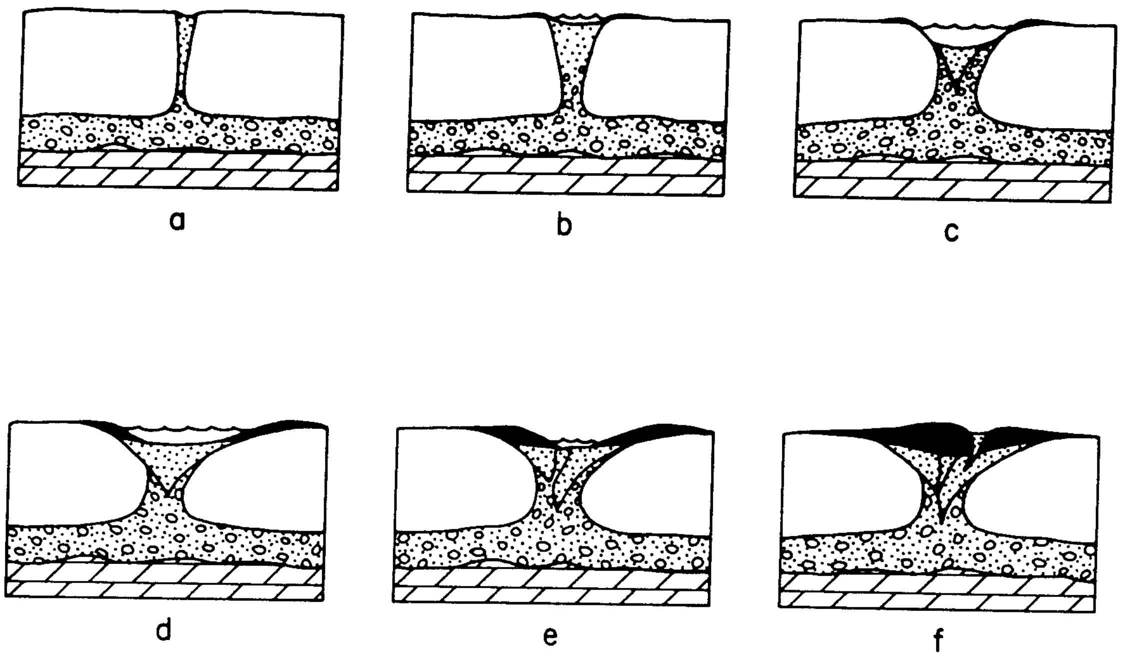


Figure 17. Diagrammatic sections showing hypothetical sequence of spring development: a, initial ascent of water from the gravel acquifer to the surface; b, conduit widens as sand and gravel is swept upward; c, widening of conduit and winnowing of feeder sand; d, formation of open pool at maximum discharge; e, accumulation of peat and vegetated mats and reduced discharge; f, compaction of peat and greatly reduced spring discharge via subfeeder.

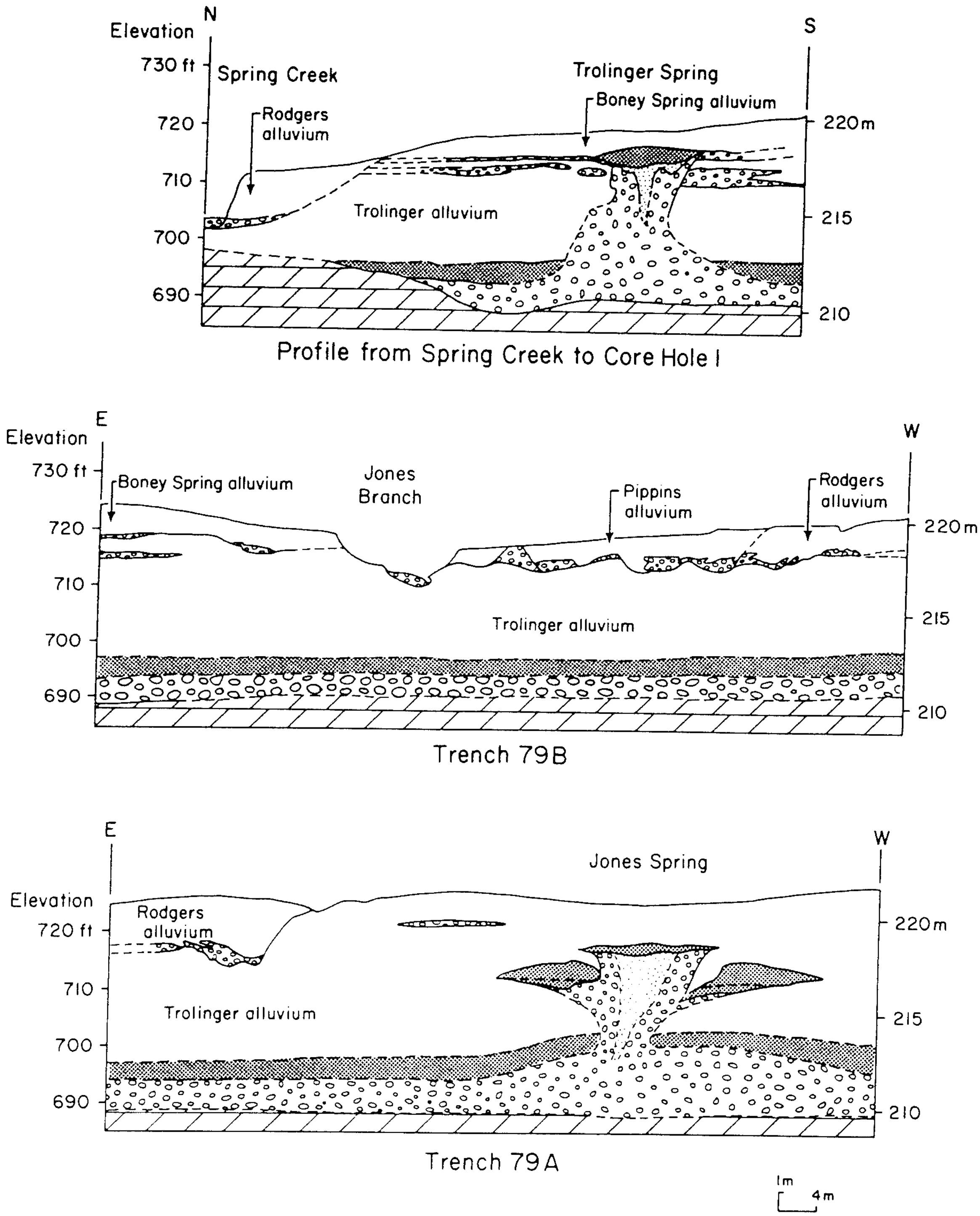


Figure 18. Geologic cross section from Jones Spring to Trolinger Spring.

gray organic layer found earlier by our coring operations to overlie the basal gravel. If they were brought up by the intruding gravel the organic carbon should be greater than 49,000 B.P., the oldest date obtained from the upper Trolinger alluvium at Jones Spring. Compatible with this interpretation are uranium series dates by Szabo (1980) of 76,000 B.P. for bone and over 100,000 B.P. for the tufa fragments in unit b.

The sand-filled feeder is undoubtedly the result of artesian discharge through the gravel. The poor sorting and angularity of some of the chert gravel, the 3 m diameter of the feeder before flaring out at the top, and the 6-8 m diameter of the gravel column all suggest forceful injection of the gravel fluidized by water under considerable hydrostatic pressure. Figure 17 shows a proposed sequence of spring development where gravel occupies a cylindrical conduit and winnowed sand forms a conical feeder. The process may start by water working its way from the gravel acquifer along some weakness (a). As the ascending flow erodes the clay-silt matrix and widens the conduit, gravel is swept into it (b). Interstitial sand is winnowed out of the gravel and carried farther up the column. Gravel lenses within the host alluvium and encountered by the ascending water have their fines winnowed out and remain in the conduit as lag gravel. At Trolinger Spring the gravel draped over the edge of the conduit under the northern edge of the peat (Fig. 16) has been affected in this manner. This stoping process would continue until the size and configuration of the feeder reached a steady state adjusted to the discharge (c). At this stage the spring is an open pool of clear water at the bottom of which is a bed of roilling, white, well sorted sand with dark rings of water-logged organic matter around active centers (d). As moss, pond weeds, and other vegetation around the pool dies, fragments are pushed to the periphery, become water-logged, and sink in the areas of quiet water. Thus, a raised rim forms from dead vegetation and

sediment trapped therein. As discharge declines the feeder sand compacts, and discharge occurs through a smaller subfeeder (e) and vegetation encroaches over inactive parts of the old feeder (e). Eventually a lens of peat covers the entire spring, and greatly reduced discharge works its way to the surface through a subfeeder penetrating the peat (f).

Micro-stratigraphy within the gravel column is made up of steeply dipping to vertical contacts separating gravels of either different shades of gray and/or grain size suggesting different episodes of movement (Fig. 6d). Similar streaks in the sand feeder represent subfeeders and indicate reduced discharge. Figure 15c shows the same phenomenon at Jones Spring. As flow velocity continues to decrease, dead vegetation and other organic matter settle to the bottom and the peat layer begins to accumulate over the white sand. Rings of water-logged vegetation around active subfeeders could be seen in miniature as our excavations exposed the feeder sand. This phenomenon was best displayed at Jones Spring when a pump failure caused resurgence of discharge (Fig. 15d).

Pulsating variations in discharge in subfeeders can cause some white sand to be deposited as thin irregular lenses over peat. Unit c at Trolinger is just such a deposit of "zebra striped" white sand and black (dark brown) peat (Fig. 14b). Peat (unit d_3) overlying this is streaked with a few thin layers of sand and is penetrated by a few small subfeeders. The micro-stratigraphy is complex, and irregular isolated patches of peat appear to be derived from an earlier peat. A truncational contact within d_3 (Fig. 16, 32 w line) may be a small compaction fault or could represent an erosional episode, but the fact that it could not be traced for more than about 3 m is consistent with the compaction fault hypothesis. Radiocarbon samples of peat either side of the contact were collected to test these two possibilities but have not been analyzed as yet. Uranium series dates (Szabo, 1980) are 36,000 and 33,000 B.P.

on the sediment, in good agreement with the radiocarbon dates, and 22,000 B.P. on bone, also in good agreement with radiocarbon dates on bone samples from unit d_3 (Table 1).

An apparent inversion in the dates is shown by a radiocarbon date of 25,650 ± 700 B.P. (T-3537) on straw and twig fragments found at the top of the feeder (unit b) and below the older peat (unit d3) dating 34,300 ± 1,200 B.P. (A-1080A). I have suggested that the straw and twig fragments, whose yellow color was in contrast to the dark brown peat, may have been stomach contents of a mastodon that fell into the spring and sank through the peat 10,000 years after its formation (Haynes, 1976). This hypothesis is further supported by the three radiocarbon dates on bone statistically averaging about 22,000 B.P. (Table 1) and the two uranium series dates of the same age.

A more obvious erosional contact separates the older peat (unit d_3) from unit e (Fig. 16, 34 w line), the younger peat at Trolinger. The stratigraphy suggests an episode of reduced discharge followed by a return to discharge about like that associated with the lower part. Had stronger discharge occurred after the erosional interval I would expect significant amounts of feeder sand to occur on the contact between them, but this is not the case.

One can envision Trolinger Spring 26,000 to 22,000 years ago as being a circular area of moss-covered peat, like the iris of the eye, over saturated feeder sand and surrounding a "pupil" of clear water seeping away from the spring through the spongey moss and semi-aquatic plants (F. King, personal communication). The vegetational mat would be weaker farther out from the conduit wall and closer to the open water. Any large animal approaching the open water would find itself literally on shakey ground and if too far out on the vegetational lip its leg would readily penetrate the mat under its own weight. Struggling would further break up the supporting mat allowing the whole body to sink

into the underlying quicksand. Anyone who has walked out onto such a spring will be fully aware of what an excellent natural trap they can be for large animals seeking water, the natural bait.

With further reduction of discharge the "pupil" would become small in diameter or become completely overgrown as the remaining discharge ascended through subfeeders. With little or no discharge the peat would compress and the feeder sand would compact reducing the trap hazard. Such was Trolinger Spring when we first observed it in 1966.

Radiocarbon dates from the 1968 excavations indicate that the earlier episode of reduced discharge occurred some time between 29,000 and 20,500 B.P. Perhaps it was during this relatively dry period that some animals fell through the peaty vegetation mat around the reduced "eye" of Trolinger Spring.

The Farmdalian substage, 22,000 to 27,000 B.P., is within this period which suggests a climatic cause. This is supported by the pollen record which shows a shift from nonarboreal pollen (NAP) and pine to spruce dominance at the top of unit e (King and Lindsay 1976). The radiocarbon date of 20,500 ± 450 B.P. (Table 1) for the middle of unit e may be too young because contamination by younger humates is indicated by the significantly younger humate dates for both unit e and d_3 (Table 1). Samples collected in 1978 are being given more rigorous laboratory treatment and should provide better time control.

Two uranium series dates on bone fragments near the basal contact of the gray clay (unit f_2) overlying the peat units are 18,000 and 15,000 B.P. and stratigraphically consistent with respect to the radiocarbon date of 20,500 ± 450 B.P. in unit e but somewhat inconsistent with respect to each other unless the contact between units d_3 and f_2 is time trangressive. In this case aggradation of the peat kept pace with vertical accretion of the gray clay.

The contact between the top of the peat units and the overlying gray clay (unit f_2) is gradational over 5 to 10 cm, but as stated earlier the peat pinches out between unit f_2 and a chert gravel lens that drapes over the edge of the conduit (Fig. 18). The thin (0-15 cm) gravel layer rests on a sharp erosional contact with the underlying clay and gravels of the Trolinger formation. The stratigraphic situation indicates that 1 to 2 m of the Trolinger formation was stripped along Jones Branch, and probably Spring Creek as well, before accumulation of the peat at Trolinger Spring began. The thin gravel layer may be a lag of colluvial gravel resulting from this erosion. Accumulation of the overlaying clay must have begun relatively soon thereafter because there is no significant buried paleosol on the contact.

The peat accumulation appears to have been before and in part penecontemporaneous with deposition of unit f_2 silty clay, which may include component of clay winnowed out of the spring, but its widespread extent in the Breshears Valley indicates an alluvial origin, probably the result of occasional high floods into the abandoned meander.

A late Wisconsinan (Woodfordian) age for units f_2, g and h is supported by the radiocarbon dates from the upper peat (unit e) at Trolinger as well as the pollen analysis from unit f_2 (King and Lindsay 1976). They represent Boney Spring alluvium in the Breshears Valley. As the peat accumulated from vegetation around the "eye" it must have been covered from time to time by floodlaid clay. Elsewhere in the Breshears Valley interbedded lenses of silty clay and chert gravels in Boney Spring alluvium were undoubtedly washed in from adjacent slopes (Fig. 5).

The varying discharge of Trolinger Spring was undoubtedly related to climatic changes, at least in part, but the origin of the spring could have been tectonic. There is no direct evidence of a fault through the northwesterly alignment of springs in the lower Pommee de Terre Valley, but it may be significant that all

of the principal springs except Phillips are on this alignment and all have an unusually high $^{234}U/^{238}U$ ratio as compared to most natural waters (Szabo 1980). In any case, glacial episodes would be times of greater hydrostatic pressure and discharge. Unfortunately we do not have any radiocarbon dates as yet for the period of maximum discharge represented by the gravel-filled conduit at Trolinger, but it could have been contemporaneous with that at Jones Spring. In this regard an age between the 48,500 B.P. date at Jones and the uranium-series dates of 76,000 and 100,000 B.P. from the conduit at Trolinger would be a reasonable estimate. It was during this time that discharge broke through to the surface, and if this was in response to increased recharge during a glacial substage it would have been an early Wisconsin substage.

This leaves a substantial hiatus between the conduit gravels and the overlying peat and raises a question of whether there had been an earlier peat deposit at Trolinger Spring, perhaps contemporaneous with the lower peat at Jones Spring. The fragments of peat within the older peat at Trolinger lend credence to this possibility which will be considered again when Jones Spring is discussed.

The erosional interval between the Trolinger and Boney Spring formations occurred probably as a result of lowering of local base level at the entrance to the Breshears Valley sometime before 34,000 B.P. and may have caused the destruction of the first peat at Trolinger. Presumably this was a time or reduced discharge of the Pomme de Terre that occurs within middle Wisconsin time (Terasmae and Dreimanis 1973). Later when the cycle swung again toward increased discharge, hydrostatic pressure on the basal gravels of the cutoff meander increased to the point where Trolinger Spring was rejuvenated before 20,500 B.P. The older peat (unit d_3) would correlate to the early part of the Plum Point interstade and the younger peat (unit e) would include part of this as well as part of the Nissouri stadial.

Jones Spring

When first examined in the dry summer of 1968 Jones Spring was simply a dried up pond (Fig. 6a) on Trolinger alluvium across Jones Branch and about 120 m southwest of Trolinger Spring. Discharge into the branch was via a small gulley a meter or so below the rim of the pond on the northeast side. Francis Kirby, former owner, said the pond had been made by deepening a wet spot in his field with a bulldozer (J. E. King, personal communication). In the summer of 1971, when the pond had its more normal complement of water, we drained it through a backhoe trench on the northeast side and dug trenches from near the center to beyond the west side revealing nearly a meter of brown peat over chert gravel and under gray and yellowish-brown clay of Trolinger alluvium.

The presence in the Jones Spring deposits of both mastodon and mammoth bones was established in 1973 when full-scale excavations began. Two peat lenses were discovered, one above the other, with indications that the larger and lower peat deposit (Fig. 6c) contained the mammoth bones whereas the mastodon bones were confined to the upper peat. However, subsequent excavations, 1974 to 1977, (Fig. 6b) provided excellent stratigraphic profiles (Fig. 19) revealing elements of both animals in both peat lenses. The sequence of events leading to the two deposits can be read from the stratigraphy.

The lower peat, a 15 m diameter lens of brown, fine-grained peat over 1 m thick (unit c), overlies a 4- by 7-meter diameter conduit filled with roughly concentric strata of sandy chert gravel (unit b) much like the configuration at Trolinger Spring. Bones of mastodon, mammoth, and bison are clearly associated with the lower peat (Saunders, in preparation), and a weak gradational contact separating the upper two thirds (unit c_2) from a gravelly lower third (unit c_1) may also separate two different species of bison according to Saunders (personal communication). The upper peat (unit e) (Fig. 15e) also overlies conduit gravels

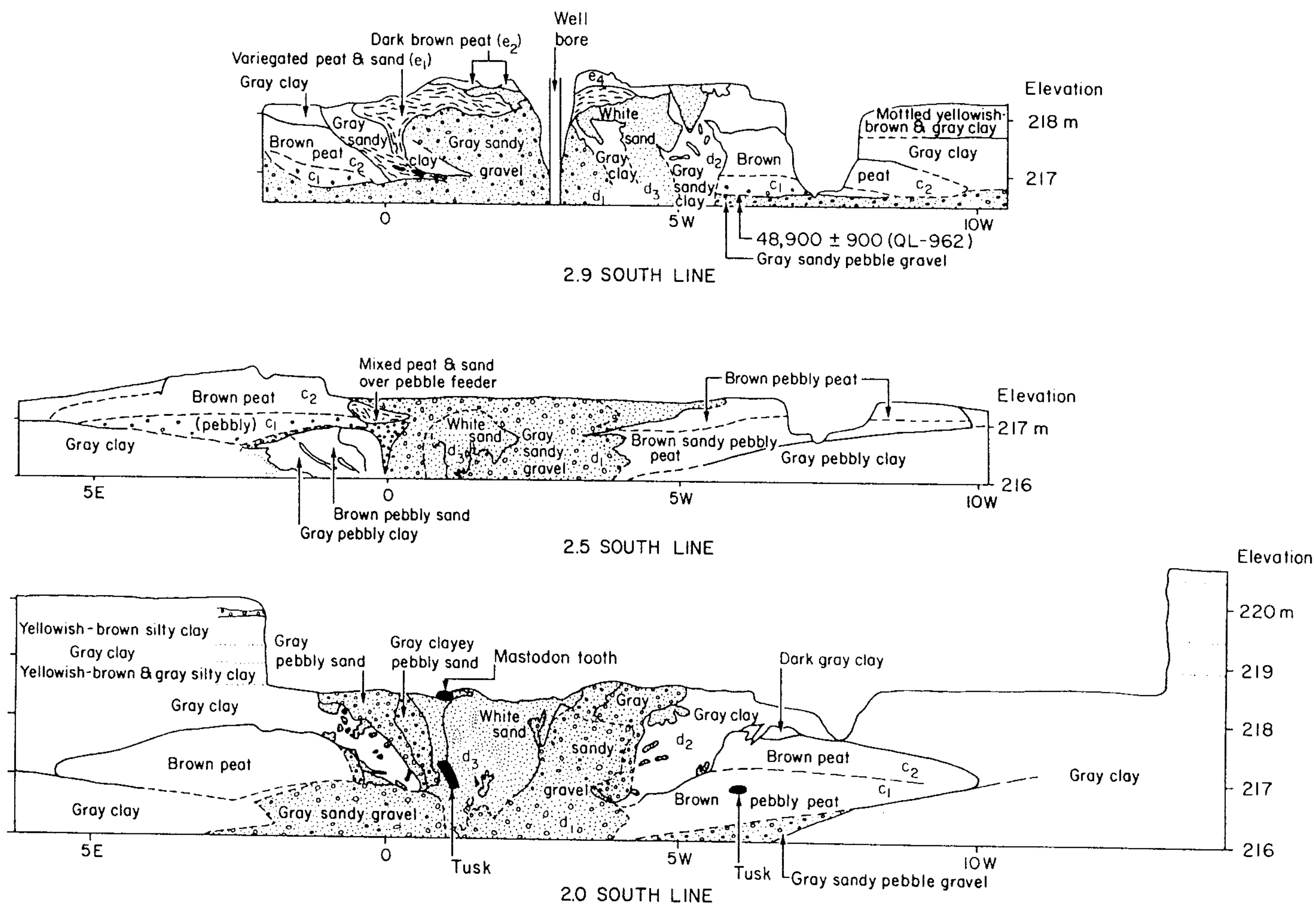
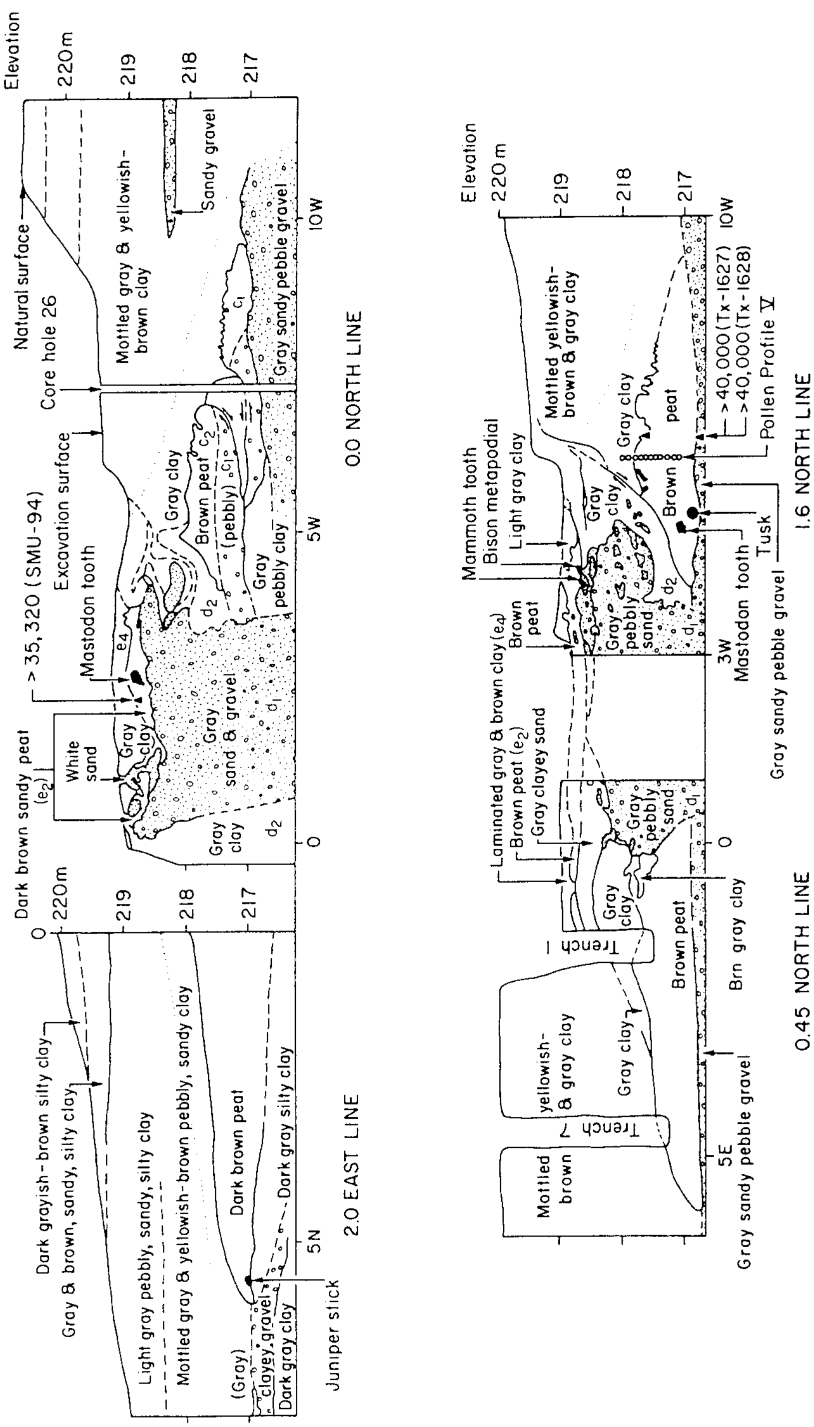


Figure 19a and b. Stratigraphic sections through Jones Spring.



JONES BOG CROSS SECTIONS

(unit d_1) but these are clearly redeposited, at least in part, from the earlier conduit because they pass completely through the lower peat (Fig. 18). The forceful nature of this intrusion is indicated by micro-reverse faults observed in the lower peat on the west side (Fig. 19, line O-N). The inner conduit gravels again display concentric strata but with considerable convolutions. The inner core consists of white, well sorted medium quartz sand (unit d_3), a typical sand feeder with accompanying subfeeders well displayed by the microstratigraphy (Fig. 15c).

The mixed nature of the conduit sediments is manifest by dispersed fragments of peat, wood, and bone some of which show considerable abrasion and which were carried up from below. Even the feeder, despite the high degree of sorting displayed by the sand, contained an isolated mastodon tooth, a large tusk fragment, and half of a mastodon jaw complete with teeth. These items apparently sank into the feeder which would have been quicksand when still active. That they were not carried up in the feeder is apparent from the contrast in grain size between the sand and the foreign objects. The sand is sorted by the ascending water, and the grain size is adjusted to the average setting velocity following Stokes' law.

The upper peat (Fig. 15e) is also a mixture, but of a very dark brown (10YR 2.5/1) to black, very organic clay (unit e_2) riddled with irregular patches of white feeder sand (unit e_3, not differentiated on Fig. 19) in places, over a striped mixture of sand and peat (unit e_1) some of which must be reworked peat, sand, and clay from below. Abraded fragments of wood, bone, and teeth may have been brought up from below during the early stages of ascent of the inner conduit gravels, but the relatively fresh, well preserved condition of some of the fossil bones suggests contemporaneity with the upper peat. Both mastodon and mammoth bones are a part of this association.

A dark gray clay (unit e_4) overlying the organic clay (unit e_2) is laminated in places and apparently represents bottom sediments of a spring-fed pond when discharge must have been slight or maybe nil (Fig. 19). I did not observe the upper contact of this unit because of its removal by mechanical equipment before I was on hand, but from other witnesses accounts it was probably transitional to the overlying upper Trolinger formation which consisted of gray clay oxidized and mottled with yellowish-brown clay (Fig. 6c) away from the reducing environment of the spring and peat deposits.

A radiocarbon date on the top of the lower peat shows it to be more than 40,000 years old and a small juniper log on the basal contact dated 48,900 ± 900 B.P. (QL-962) (Table 1). The upper peat, being a mixture, may not be reliable for dating, but a date of greater than 35,320 (SMU-94) is consistent. Organic clay filling the nerve canal of a tusk from this level dated 31,130 ± 1,550 B.P. (SMU-99) which is too young considering that this is approximately the same date as samples from the lower peat (unit d_3) at Trolinger which post dates erosion of the Trolinger formation.

At Jones Spring aggradation of Trolinger alluvium appears to have continued after deposition of the upper peat. No pronounced erosional contacts were seen in the overlying clay and the surface soil is more developed than in Boney Spring alluvium over Trolinger Spring.

In retrospect, Jones Spring appears to have burst forth at a time when about half of the thickness of the Trolinger formation had been deposited. A stratigraphic break (unit c_2/c_1 contact) within the lower peat, while not very pronounced, appears to separate a significant faunal change which implies a time break during which there was no deposition of peat. This further implies that discharge of the spring was severely reduced or had stopped as had aggradation of Trolinger alluvium because the peat lens does not show any extensions of

Trolinger clay into it as would be expected if the lower part of the lower peat (unit c_1) had been flooded before deposition of the upper part (unit c_2). The absence of a clearly defined contact and buried soil beyond the edges of the peat may be due to either the shortness of the break or to the blending effects of the saturated ground (gleying) since burial.

After an unknown duration there was renewed peat accumulation presumably in response to renewed spring discharge. Bison, in association with mammoth and mastodon at this time, were apparently a smaller species (cf. antiquus) than in the lower part of the lower peat (cf. latifrons) (Saunders, personal communication). Eventually, the peat settled and compacted as discharge declined and possibly stopped altogether. The absence of fossil pollen in the lower peat suggests that it had dried out at one time causing oxidation and destruction of pollen grains that must have been present.

Eventually pressure on the underground water system increased to the point where it burst through the center of the lower peat lens and swept sand and gravel through it to establish a new conduit with sand feeders and capped by the upper peat with intermixed sand and clay. Bones, teeth and fragments thereof were swept upward and redeposited in higher levels. During a later phase of reduced discharge via subfeeders some mastodon bones worked their way downward and came to rest in the sand feeder. The final phase of Jones Spring appears to have been a small pond over the upper peat that eventually was buried under 2 m of Trolinger alluvium.

As mentioned earlier there may have been an earlier discharge phase at Trolinger coinciding with one of those at Jones. The predominance of mammoth, bison, and horse remains in the conduit gravels at Trolinger compared to mastodon, muskoen, etc. in the peat supports an earlier history of spring activity.

To clarify the stratigraphic relationship between Jones and Trolinger Springs, backhoe trenches (79 A and B) were made from Jones Spring eastward across Jones Branch (Fig. 2). These provided a nearly continuous section between the two springs (Fig. 18) that reveals three alluvial cut-and-fill events following aggradation of Trolinger alluvium. The first was the erosion preceeding formation of the peat at Trolinger Spring followed by deposition of Boney Spring alluvium over the peat by floodwaters entering the cutoff meander. Between Jones Spring and Jones Branch the trenching revealed 3 m of Rodgers alluvium which was cut-and-filled by 1.5 m of Pippins alluvium (Fig. 18). Terrace remnants of these units occur along Spring Creek, but, strange as it may seem, Rodgers alluvium does not extend up Spring Creek much beyond the confluence with Jones Branch, which has only about a third of the drainage area of Spring Creek. Trenches across the floodplain of Spring Creek upstream from the Breshears Valley revealed Boney Springs alluvium inset into Trolinger alluvium but no Rodgers or Pippins alluvium.

Kirby Spring

West of Jones Spring about 350 m is an elongated depression measuring 27 m east-west and 5.5 m wide containing a pond almost completely choked by cattails and other plants including a willow tree (Fig. 4f). This spring with a seepy outlet to Spring Creek 30 m north we called Kirby after the last owner before purchase by the government. An 1845 land survey map is marked, "Big Bone Diggings" at the site of Kirby Springs, which is probably the diggings referred to in history of Benton Country (Lay 1876) as being worked by two brothers named Bradley (McMillan 1976a).

Our test excavations in 1973 revealed that most of the deposits were thoroughly disturbed and no bones remained, but a peat layer did extend out from

the spring on the eastern edge and under a meter or more of gray clay. Radiocarbon dates show the peat to be more than 37,000 years old (Table 1) and fossil pollen indicates vegetation like that of today and unlike any other pollen profile in the Pleistocene deposits. These facts suggest that the sediments at Kirby Spring may be interglacial (Sangamon?) and, in any case, older than the lower peat at Jones Spring, because there is no known Wisconsinan substage with an essentially modern pollen spectrum. If this is the case, then there must be a significant cut-and-fill relationship between an older Trolinger alluvium at Kirby and a younger one at Jones because the two springs are at essentially the same elevation. A special effort is being made to obtain maximum limit radiocarbon analyses from the Kirby and Koch peats, and wood from the conduits at Jones and Trolinger Springs.

Koch Spring

In 1971 we drained Koch Spring (Fig. 4e) by pumping from wells placed near it and drawing down the local water table. A north-south trench through the center of the spring exposed a brown (10YR 2/2) peat lens under 2.5 to 3 m of gray (5Y6/2, 5/2) clay with chert gravel lenses, itself over interbedded clay, sand, and gravel (Fig. 13). The entire central part of the spring had been disturbed by Koch's and later excavations, and only a few fragments of bone and tusk were found in the mixed, pebbley clay and peat of the disturbed zone overlying the conduit area. This zone also contained a platform made of two layers of split wood rails, one layer at an angle to the other, that apparently served as a footing for previous excavators in removing fossil bones from what must have been a very muddy spring. Most of the split rails were good quality walnut indicating its abundance then compared to today. A chert flake and a bifacial

preform were found in the mixed layer and, like the artifacts found by Koch, probably derive from the late Archaic occupation in evidence around the spring (Wood, 1976).

As mentioned earlier the peat lens at Koch Spring is interbedded with Koch alluvium forming an 8.5 m terrace a half meter of which is overbank deposition of Rodgers silt. Radiocarbon dates from the peat are 31,800 ± 1,340 B.P. (Tx-1412) from the middle of the peat and greater than 38,000 B.P. (Tx-1457) from organic gray clay below the peat (Table 1). The younger sample was what appeared to be short fragments of yellow straw and vegetable fiber (Fig. 15f) that could be from the intestinal track of a mastodon or other large animal that fell into the spring and that is intrusive to the peat, like the situation at Trolinger Spring. If this is the case then the peat itself is older and it would be likely that all of the Koch formation is older than 32,000 B.P. If, on the other hand, the upper date is correct for the middle of the peat, the top would be younger which raises the possibility of falling into the time of Boney Spring deposition. This does not seem likely, however, because the 30,000 B.P. level at Koch Spring would be near the top of the alluvial terrace whereas it is probably at the base of the terrace at Boney Spring as described later.

Most of the peat has NAP and pine pollen but the top samples show a significant increase in spruce pollen much like that at the top of the younger peat (unit e) at Trolinger Springs at about 20,000 B.P. (King 1973). However, I do not believe it is likely that the top of the peat at Koch Spring is this young for the reason just stated plus it would mean an unusually long period of time is represented by the Koch peat. Furthermore, Koch alluvium at Koch Spring does not have the olive colors so typical of Boney Spring alluvium (Brakenridge 1979, 1981). The final decision must await analysis of other radiocarbon samples of Koch peat now in process. Until then I am inclined to believe that Koch peat

and alluvium represent a dry to wet cycle within the Altonian substage of Frye and Willman (1973), possibly the Cherrytree stadial of Terasmae and Dreimanis (1976).

Because of the severe disturbance of Koch Spring it could not be determined if multiple discharge events had occurred as at Jones and Trolinger Springs or if discharge had at one time stopped all together before final aggradation of the Koch Terrace. As stated earlier, the terrace is covered by up to a meter of Rodgers silt, but the full thickness of Rodgers alluvium is not developed at the spring. Instead lower Pippins alluvium is inset against the Koch Terrace and contains organic deposits formed in a slough that was in part spring fed (Fig. 13). The organic sediments provided dates of between 840 and 620 B.P. for this episode of aggradation (Table 1).

Boney Spring

The 6.4 m terrace containing Boney Spring (Fig. 6e) 3 km northwest of the Breshears Valley (Fig. 2), is inset against a remnant of a higher terrace that appears to be Koch alluvium resting against the dolomite bluffs. The spring, which had a bouncy vegetation mat around a small "eye" of water in 1966, is in Boney Spring alluvium between the older terrace and Rodgers alluvium which extends over the springlaid deposits (Fig. 9, F-F[1]).

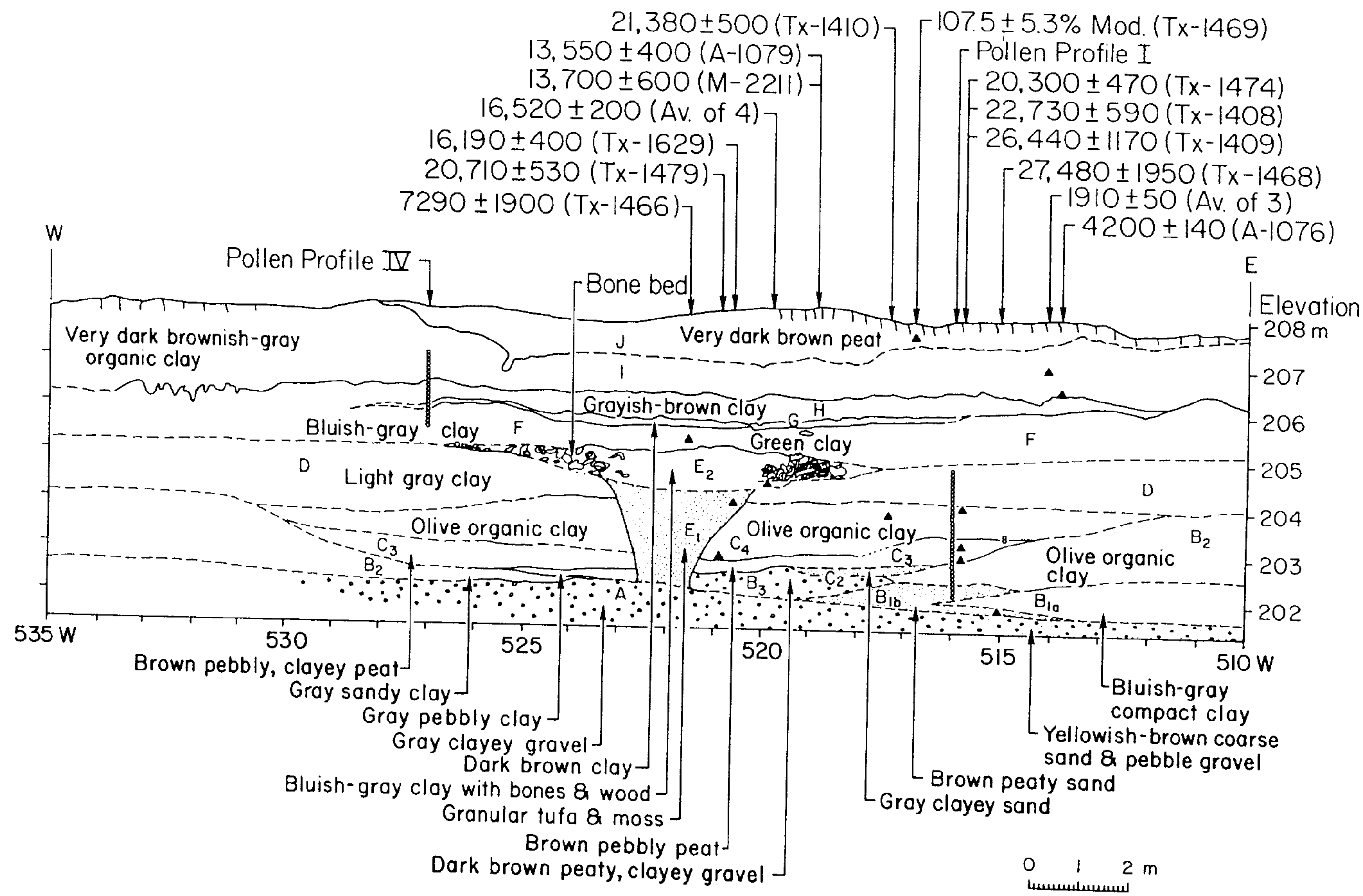
Taphonomic excavations of Boney Springs in 1971 uncovered mastodon bones representing 31 individuals (Fig. 6f) concentrated in a 0.7 m thick lens around a 2 m diameter feeder filled with calcareous coarse sand composed of granular tufa (Saunders 1977a). The funnel-shaped feeder constricts to a diameter of about 1.2 m at the bottom which is on gravel 5.5 m below the surface (Fig. 20). The blue chert gravel does not, however, extend up a conduit around the feeder as at Trolinger and Jones Springs. Five core holes along a line extending

westward from east of the spring almost to the river show the basal gravel to extend all the way to the river with a thickness of 2 to 3 m (Fig. 9, F-F[1]). The basal gravel is overlain by bluish-gray (5Y7/1, 5/1) and olive gray (5Y5/3, 4/1) clays with interbedded organic clayey sands and gravels and a brown pebbly peat (unit C_3) in the lower part of the section (Fig. 20). This entire section is one of vertical accretion. Fortunately, the occurrence of wood and organic samples allowed much of the succession to be radiocarbon dated (Table 1).

The base of unit B_1 provided dates of 24,460 ± 10,000 B.P. (Tx-1467) on peaty sand and 27,480 ± 1,950 B.P. (Tx-1468) on soluble humates extracted therefrom. Neither date is satisfactory because of the imprecision of the first and possible secondary origin of the second, but both are consistent with respect to the date of 26,440 ± 1,170 B.P. (Tx-1409) on wood from the second unit (C_3), the peat, above unit B_1. The contact between units C_1 and C_2 – C_3 is sharp and appears to truncate unit C_1 (Fig. 20). If so a significant hiatus is represented, and the lower units (B through C_1) could be basal Koch alluvium.

The upper part of the C_3 peat is dated at 22,730 ± 590 B.P. (Tx-1408) and a date of 28,330 ± 3,140 B.P. (Tx-1407) on associated humates shows the mobility of soluble organic matter, probably a mixture, throughout the more permeable zones. Olive organic clay (unit C_4) overlying the peat has a basal date of 20,710 ± 530 B.P. (Tx-1479), a mid-section date of 21,380 ± 500 B.P. (Tx-1410), and a top date of 20,300 ± 470 B.P. (Tx-1474) all on wood. Two successive extractions of humates from the latter provided dates of 17,320 ± 1,810 B.P. (Tx-1475) and 19,550 ± 1,080 B.P. (Tx-1476), showing the mixed nature of the soluble fractions.

No suitable radiocarbon samples occurred in unit D, but several logs at the base of the bone bed (unit E_2) provided four dates all within one standard deviation of 16,500 B.P. (Table 1). Therefore, formation of the spring feeder



EAST-WEST GEOLOGIC CROSS SECTION OF BONEY SPRING, MISSOURI

1971

(Sections of lines 478N & 480N superimposed)

Figure 20. Stratigraphic section through Boney Spring.

occurred before this date but after 20,000 B.P. Correlation of this event with the Wisconsin glacial maximum of 18,000 B.P. is supported by the pollen data (King 1973).

The bone bed rests directly on the spruce logs and therefore post-dates 16,500 B.P., as well as moss from the feeder dating 16,000 ± 400 B.P. (Tx-1629) which is probably derived from a live mat that existed around the "eye." Encrustation of the moss by calcium carbonate (tufa) suggests loss of carbon dioxide from the spring water either by evaporation or repeated wetting and drying by a fluctuating water level. Reduced discharge is indicated by either event, and the occurrence of divided tufa and moss fragments in the feeder indicate decay of the moss mat and break up of the tufa associated with a decline of discharge.

From careful excavation and detailed analysis of the bone bed Saunders (1977a) concluded that the animals died after 16,200 B.P. during a time of stress caused by drought and that many bones must have been exposed on the surface for some time as indicated by their weathered condition. Unfortunately, the gray clay matrix of the bone bed is devoid of fossil pollen that would shed more light on the conditions that existed at the time of bone accumulation, but the nerve cavities of several tusks were filled with a dark brown organic clay containing pollen of a mixed spruce and deciduous tree flora dated about 13,600 B.P. (Table 1). A similar pollen spectrum was found in a small lens of similar material within the bone bed (King 1973). The filling of the tusks occurred after the bone bed had formed and after the tusks had become separated from the skulls, presumably upon weathering. The organic clay is apparently from a unit that formed over the bone bed during a time of moderate spring discharge following a period of reduced discharge.

These data imply a sequence of relative spring discharge varying from high discharge between 20,000 and 16,500 B.P., low discharge about 16,000 B.P. and moderate discharge until after 13,500 B.P. when the Boney Spring terrace (T-1b) was abandoned. Leighton (1960) called an interstage between Tazewell and Carey stages the St. Charles interstage (16,000 to 15,000 B.P.), and Mörner and Dreimanis (1973) described the Erie interstadial occurring in the same time interval between the Nissouri and Port Bruce stadials of the St. Lawrence region. As at Trolinger Spring, there does appear to be a correlation between glacial advance and spring discharge which reflects increased recharge of the acquifer supplying the spring.

A green clay (unit F) over the bone bed at Boney Spring contained a few flecks of scattered charcoal that dated 7,290 ± 1,900 B.P. (Tx-1466). This and overlying units (F, H, and I) appear to be overbank alluvium from the Pomme de Terre River modified by spring discharge. The top most unit (J) is a dark brown peat incorporating a Woodland Indian site with three radiocarbon dates of approximately 1,910 B.P. (King and McMillan 1975) and a basal date of 4,200 ± 140 B.P. (A-1076) (Table 1).

Phillips Spring

No sand filled feeder or gravel conduit occurs at Phillips Spring which consisted of a bed of moss over water in the center of a small depression 80 m from the edge of the Pomme de Terre River. Discharge was to the river via a small gulley that may have been artificial. As mentioned previously the upper 2 m of strata around the spring contained numerous archaeological features and artifacts (Fig. 10).

The intense human occupation has disturbed the stratigraphy and obscured erosional contacts, but the spring is apparently due to a buried bulge in the

basal gravel which brings the top of the acquifer closer to the surface at that point. The bulge is buried by Rodgers alluvium with a complex history of cutting and filling (Fig. 8, C-C[1]). It is quite possible that Phillips Spring may at one time have been a more typical spring, like Trolinger Spring, that was severely eroded during a major episode of degradation during which the feeder and overlying organic deposits were swept away leaving only the conduit gravel as a lag deposit. A 4.5 m deep stratigraphic trench (Fig. 12) revealed organic clay in the basal gravels that yielded a radiocarbon date of 25,350 ± 440 B.P. (SMU-813). The soluble humate fraction was dated so the age is imprecise, but it does support a pre-Rodgers age for the basal gravel at Phillips Spring as does a pollen spectrum of 98-99% pine pollen (J. E. King, personal communication).

Such an origin would explain the absence of feeder sand; once swept away it would not be likely to reform because most of the sand had already been winnowed out of the gravel. Spring discharge would have kept pace with aggradation of Rodgers silt over the gravel bulge except when disturbed by one or more of the erosional episodes during Rodgers time.

DEPOSITIONAL ENVIRONMENTS AND CORRELATIONS

From the detailed stratigraphy and radiocarbon dates presently available it is useful to compare top stratum character, volume, deposition rates, and terrace heights for each fill over the past 100,000 years or so. These data are presented in Table 2.

The relatively uniform, fine-grained character of the Trolinger alluvium, with only minor tongues of interbedded colluvial gravels all over a relatively thin bed of basal gravel, suggests deposition by a stream that was not meandering; one more like the present river, although perhaps larger, which is made up of essentially straight segments with pools and riffles within the incised meanders of the ancestral river and which aggrades by overbank deposition. Vertical accretion appears to have been the predominant depositional mode of aggradation up to the present day. From the stratigraphy at Jones and Trolinger springs and the very low rate of deposition it appears that the Pomme de Terre was gradually aggrading (net rate is 0.03 cm/yr) throughout the vegetational change from Juniper woodland 50,000 B.P. through open pine parkland up to 30,000 B.P. (King and Lindsay, 1976). Because of a lack of adequate dates on Kirby peat and basal Trolinger formation earlier depositional rates cannot be determined. The source of sediment within the drainage basin at this time is not known. Possible sources are slope washed loess, destruction of vertical accretion deposits of T-3, and stripping of upland soils including terra rosa and limestone residuum. Colors are generally those of reduced oxidation states that still prevail except where oxidized under pedogenic conditions at the surface.

All radiocarbon dates older than 26,000 B.P. are on either peat itself or wood from one of the peat lenses. In evaluating a radiocarbon date on whole peat one must consider that the date is an average for the accumulation of

Table 2. Alluvial Data, Pomme de Terre Valley

	FLOODPLAIN						
		Average (meters)		Deposition Rate (mm/yr)			Average Channel Width
Formation	Thickness	Width	Area*	Max.	Min.	Av.	
Pippins	4.0	198	548	10.0	2.0	5.0 (3)**	61
Rodgers (R_2-R_5)	7.0	396	1920	6.0	0.5	2.0 (7)	122
Rodgers (R_1)	4.6	---	---	---	---	2.0 (1)	
Boney Spring (C_4, D, E_2)	4.6	412	1310	0.4	0.2	0.3 (5)	127
Boney Spring peat (C_3)	0.3	---	---	---	---	.08 (1)	
Koch	6.2	380	1637	---	---	0.6 (1)	117
Trolinger	9.1	610	---	---	---	0.3 (1)	100
Trolinger peat (d_3)	2.0	---	---	---	---	0.03 (1)	

*Area determined by (floodplain width x thickness) X (Channel width x thickness)
**Number of determinations based upon occurrences of two or more pertinent radiocarbon dates in a particular stratum.

fragments of moss, semi-aquatic plants, pondweeds, etc. over the time represented by the thickness sampled, usually 3 to 5 cm. At Boney Spring two dates on wood from the upper and lower parts of the peat (unit C_3) provided a means of estimating an accumulation rate of 0.008 cm/yr. which amounts to 375 to 625 yrs. for the thickness usually sampled. In the case of the Boney Spring peat this is less than the standard deviations of the radiocarbon dates and not, therefore, significant.

Radiocarbon dates on pieces of wood from peat deposits may not be representative of the host peat if they have intruded the peat by gravity (falling tree limb) or through animal tramping which would also churn up the peat and thereby disrupt any layering. A case in point is the modern radiocarbon date on a stick from the lower Pippins formation at Koch Spring, Trench V-5 (Fig. 13).

In regard to layering, it is possible, if not probable, that some peat accumulates not in roughly horizontal layers but in inclined layers as floatsam is pushed by roiling water to the periphery of a spring pool or "eye." Samples were collected at Trolinger Spring in 1979 to test this hypothesis and until the results are known these caveats must not be forgotten.

Except for the top sample or two from five of the ten pollen profiles in peats most of the peat deposits represent relatively warm intervals of reduced spring discharge that probably correlate with interstadials in the glaciated areas to the north. The peat (unit C_3) at Boney Spring is a convincing example because the pollen is dominated by NAP-pine (King, 1973) and the radiocarbon dates are essentially the same as for the Farmdalian Substage (Frye and William, 1973).

Similar problems arise with correlation of the interstadial represented by the Koch peat. It could have formed during either the Plum Point or Port Talbot II or even some earlier interstadial if its stratigraphic position has been misinterpreted as explained earlier.

The deposition rate of 0.06 cm/yr for Koch alluvium in Table 2 is based upon age estimates of 40,000 to 32,000 for deposition of 6.2 m of topstratum. The age estimates are tenuous at best. In fact, until maximum ages are obtained for samples presently in process for Jones, Kirby, Koch, and Trolinger peats none of the proposed correlations for early and middle Wisconsin time can be selected with any assurance.

After 29,300 B.P. there is a 3,000 year hiatus during which T-2 was abandoned and the river degraded. There is no vegetation record for this period unless it is the base of the Boney Spring section (units B and C_1) and top of the older peat at Trolinger (unit d_3), but timewise it may correlate with the transition in the eastern Great Lakes region from the Cherrytree Stadial to the Plum Point Interstadial. Much of the older peat (unit d_3) at Trolinger may correlate with the early part of the Plum Point Interstadial.

The Pomme de Terre began to aggrade (Boney Spring alluvium) again shortly before 26,000 B.P. during another period of open pine parkland that correlates well with the Farmdalian substage, as mentioned previously, and continued to do so through the pollen-record change to spruce forest at essentially the same rate (0.03 cm/yr net) as during Trolinger time. By 16,500 B.P. aggradation of $T\text{-}1_b$ had ceased and a period of quasi-stability persisted for about 3,000 years for which we have no pollen record. All we can say is that the forest cover changed from spruce dominance to a mixture of spruce and deciduous trees by 13,500 B.P. A lower water table during this period is inferred from the marked reduction of spring discharge, and Saunders (1977a) infers a drought that terminated most of the Pleistocene megafauna during the early part of this period in the Ozark Highland.

Aggradation of Boney Springs alluvium took place during a time that Terasmae and Dreimanis (1976) call the Nissouri Stadial and the last part of the preceding

Plum Point Interstadial. During the most intense part of the late Wisconsin glaciation, 18,000 B.P., the Pomme de Terre floodplain was approaching a state of quasi-equilibrium approximately 6 m above the modern stream bed. The cessation of aggradation and the inferred dryness soon after 16,500 B.P. occurred at essentially the same time as the relatively dry Erie interstade of about 15,500 B.P. (Morner and Dreimanis, 1973). After 13,000 B.P. the river degraded and eroded its banks for a period of about 2,000 years during which much of the Boney Spring alluvium must have been removed to account for its scarcity in the valley. At the same time the Port Huron advance followed by Two Creeks retreat occurred to the north.

Six epicycles of cutting and filling of brown clayey silt occurred within Rodgers alluviation between 11,000 and 1,400 B.P. Alluviation of about 7.2 m of the earliest Rodgers fill (R_1) occurred during the substages of deglaciation that followed the Twocreekan substage. The rate of deposition (0.2 cm/yr, Table 2) is an order of magnitude greater than for either Koch or Boney Spring alluvium.

At Rodgers Shelter deposition of talus beneath the protective overhang occurred between 11,000 and 10,000 B.P. or possibly somewhat earlier but was a minor factor thereafter. The tabular dolomite clasts rest parallel to the talus slope thus clearly defining the sequence of gradual accumulation (Ahler, 1976) and precluding deposition by stream flow, soil creep, or debris flow. A trench (76-A) on the T-1_b terrace to the west and outside of the shelter revealed colluvial gravel that differs from that under the overhang in being less flaggy and more dispersed (Kay, 1980). Therefore, the talus of units A^2 and B^1 appears to be peculiar to the shelter, possibly the result of ablation from the roof. If production was not the result of root action or efflorescence due to wetting and drying but of frost action, as seems more likely, more freeze-thaw cycles

are implied for this period than any since then. What this means in terms of climate is less clear. Farrand (1975) has pointed out some of the problems with climatic interpretations of rockshelter deposits, but the necessity for data on rates of deposition should also be emphasized. A slow rate of alluviation can cause an increased percentage of colluvium, but this is not the case in Rodgers Shelter because the rate of deposition of the clayey silts (units A^1m B^2, and C) of Stratum 1 remained essentially the same during and after deposition of the talus (Table 2).

During the Hypsithermal interval, as redefined by Wright (1976), 5.2 m of Rodgers alluvium (R_2) was laid down at a depositional rate of about 0.25 cm/yr at Phillips Spring and buried the remnant of T-1_b at Boney Springs and R_1 at Rodgers Shelter where the deposition rate for Stratum 2 was only 0.1 cm/yr. The slow rate at which Stratum 2 was deposited in the shelter is consistent with the greater degree of pedogenesis apparent in it. The earliest part of R_2 deposition at Phillips Spring has the highest rate of deposition, 0.63 cm/yr, determined so far. As would be expected, the latest part was deposited at a slower rate; about 0.09 cm/yr. As the floodplain aggrades the chances of overbank flooding and vertical accretion decrease (Wolman and Leopold, 1957, p. 97).

An erosional hiatus of no more than 1,000 years occurred during the transition from Hypsithermal to Neoglacial climates. Subsequent fills of Rodgers alluvium (R_3 through R_6) were deposited at rates 0.05 to 0.08 cm/yr (Table 3) through the transition from Hypsithermal to Neoglacial climates and during the Neoglacial as defined by Porter and Denton (1967). At Rodgers Shelter overbank deposition may have reached Stratum 4 on rare occasions but deposition of colluvium predominated during Late Archaic and early Woodland occupations.

After an erosional hiatus of no more than 200 years the first deposition of Pippins alluvium (T-0a), about 4 m of silty sand, occurred at an average rate of 0.5 cm/yr which was followed in less than a century by cutting and then filling of T-0b at 1 cm/yr.

Over the past 50,000 years alluviation of the Pomme de Terre is separable into four periods differing mainly in rates of aggradation and the character of the vertical accretion deposits. The Trolinger, Koch, and Boney Spring formations are more clayey and chemically reduced than Rodgers alluvium and were laid down at much slower rates, although part of this could be attributed to the invisibility of epicycles of alluviation within each deposit cut-and-fill contacts having been erased by the effects of time. For comparison the net aggradation rate of Rodgers alluvium as a whole is 0.19 cm/yr, still greater than any of the earlier terraces but less than half that for Pippins alluvium (Table 2). Pippins alluvium is coarser and less oxidized than Rodgers (Brakenridge, 1979, 1981) and has the smallest volume and highest deposition rate (0.52 cm/yr).

Relationships of floodplain dimensions to channel dimensions are not known for the older terraces of the Pomme de Terre River, but if they were proportional to T-0 and the modern channel the relative size of past channels can be estimated by equating ratios of channel width to floodplain width:

$$\frac{C_p}{F_p} = \frac{C_r}{F_r} \qquad C_r = \frac{C_p F_r}{F_p}$$

when C_p is modern channel width, F_p is historic floodplain (Pippins) width, C_r is Rodgers channel width and F_r is the width of the Rodgers floodplain. The results (Table 2) suggest that there was little difference in channel dimensions during Rodgers, Boney Spring, and Koch time, and probably, therefore, discharges were of the same order. The channel widths were approximately twice

that of the modern Pomme de Terre suggesting that average annual discharges were significantly greater than the 17.4m^3/sec for the period of record (1912-1960) (U.S.G.S., 1961).

Channel width and discharge are even more tenuously estimated for the Trolinger formation because the deposits in the Breshears Valley are a special case of vertical accretion in a cut off meander. With this in mind I estimate the channel width to have been half again wider than during Koch, Boney Spring, or Rodgers time (Table 2) therefore indicating greater discharge.

The increase in both grain size and rate of deposition from mid-Wisconsin time to the present is probably related to changing soil conditions over the approximately 2,000-km^2 catchment. The Koch, Trolinger, and Boney Springs clays may be due to the filtering effect of grasses and other small plants on slope washed loess. Pollen profiles consistantly show 5 - 10% grass pollen which would undoubtedly be considerably higher if the constraints of pine and spruce were removed. The relatively high content of well-preserved pollen in both Koch and Boney Springs sediments indicates that the reducing conditions have persisted since deposition. This is undoubtedly due to their being within the zone of saturation and indicates higher ground water which is consistent with the evidence of greater discharge from the springs than at any time since. Adjacent hillslopes may, therefore, have been moister with more seeps, soil, and grass cover than during Rodgers time. Part of the soil cover probably consisted of loess because the Breshears Valley is within the area of loess accumulation (Thorp, Smith and others, 1952), and loess has been traced into the area via drill-core sampling from thick outcrops north of the Missouri River (Johnson, personal communication). Brakenridge (1979) presents evidence, based partly upon clay mineralogy, that both the Boney Springs and early Rodgers formations contain significant components of reworked loess, and an aeolian origin for silt in the early Rodgers formation at the shelter was suggested by Ahler (1973, 1976).

No adequate pollen record exists for the early part of Rodgers alluvium, but there are records for the equivalent period from elsewhere in the region (King and Allen, 1977), and there is one grab (expediency) sample from the 7,800 B.P. level (R_2) of the Rodger terrace at Phillips Spring. These show a marked vegetational change coincident with Rodgers alluviation. The relatively rapid appearance 10,000 to 11,000 years ago of the oak-hickory dominated forest was probably in part related to a reduction in the water table indicated by the oxidized sediment. This would likely have been accompanied by a reduction in seeps and plant cover on the valley sides, and Rodgers silt may reflect an increase in slope-wash sediment. Brakenridge (1979, 1981) recognizes loess deposition during Rodgers time.

Stripping of a significant percentage of the plant substrate on slopes and the creation of unstable edaphic conditions may have been caused by more intense rain storms and, therefore, more concentrated runoff during Holocene time than had occurred during the Wisconsin. On the basis of faunal evidence, McMillan (1976) suggests that there was a gradual trend to increased grassland at the expense of forest from 8,600 to 5,000 B.P. and Purdue (1980) found clinal variation in some mammals at Rodgers Shelter that suggested a mesic early Holocene, less mesic middle Holocene, and essentially modern conditions in late Holocene time. The peak in numbers and variety of grassland vertebrates occurred at the base of Stratum 2 around 8,000 B.P. when the river was beginning to aggrade (R_2). Fluctuations of these conditions and the removal of successive increments of slope soils in response to climate are probably the primary cause of the alluvial cut-and-fill cycles seen in Rodgers alluvium. By the end of Rodgers time most of the slope soils may have been removed and redeposited as alluvium. The resulting relatively rocky slopes would be even less effective in holding back runoff which may account for the coarser character of Pippins alluvium and the greater frequency of cut-and-fill cycles with time.

The basal gravels are essentially the same for all post-Breshears formations and are likely derived from reworking of T-3 gravels during each episode of alluviation. Unlike T-3 there is no evidence of lateral accretion in the strict sense (point bar structure), but adequately long exposures are lacking. It is quite possible that the basal gravels are simply longitudinal pool and riffle deposits that were more or less reworked during flood stages of each cut-and-fill cycle. The present chert-gravel bed load appears to be inactive except during times of high discharge from the Pomme de Terre dam.

For Trolinger, Koch, and Boney Spring deposits, source material color does not appear to have had much influence on the vertical accretion sediments because the red colors of T-3 did not carry over or if they did they were subsequently reduced. The reddish browns of Rodgers alluvium are in part due to oxidation as indicated by the gray, reduced state in the saturated zone of Rodgers Shelter and by the absence of fossil pollen in the aerated zone in spite of many attempts to recover it. The brownish gray color of Pippins alluvium appears to be due to a combination of its freshness, organic content, and, in some cases, dispersed charcoal which may indicate an upsurge of forest fires possibly set by Indians to improve the forest for game (King, 1977).

Surface colors of the chert gravels clearly reflect oxidation states. In most cases those at the base of Trolinger, Koch, and Boney Springs top strata and in their spring conduits are dark bluish gray (5B 4/1 on the Munsell gley color chart) indicating reducing conditions whereas those of the Breshears formation and basal Rogers and Pippins are typically oxidized to a strong brown color (7.5YR 5/7) much like the present bedload. Very likely, all of the bluish gray gravels were derived from the reworking of brown Breshears gravel. It appears that reduction occurs once the gravels become inactive and isolated within anerobic waters (older ground water?), but the color change from brown

to gray apparently takes thousands of years to complete. The reverse process is apparently much faster because the modern bedload, with few exceptions, is oxidized. The few exceptions are where chert pebbles are mottled brown and bluish gray and appear to represent a transitional stage.

The best example of the phenomenon is at Phillips Spring where the deep stratigraphic trench (Fig. 12) exposed brown chert channel gravel in the 8,000 year-old channel cut into bluish gray chert gravel about 25,000 years old. It is not known whether the brown gravel was swept over the gray gravel or was a result of the reworking and oxidation of the older gravel. It was likely a combination of both.

Discussion

It appears that no clear one-to-one correlation of the alluvial events of the Pomme de Terre to climatic events implied by the glacial record is possible for the Early and Middle Wisconsin. More finite radiocarbon dates are needed beyond 40,000 B.P., but maximum spring discharge appears to correlate with glacial maxima unless tectonics is involved. Spring discharge partly follows and partly coincides with vertical accretion implying more and/or larger overbank floods. The spring peat deposits form during periods of reduced discharge and less mesic climate corresponding to interstadials, but as Tables 3 and 4 show, precise correlations are equivocal. More mesic pollen at the top of some peats may indicate intrusive contamination or renewed accumulation of peat, but a change to more mesic conditions is indicated in either case. The gravels and few remains of fine grained facies of the Breshears formation (T-3) represent a more vigorous river than any stage since their deposition. They are probably pre-Wisconsinan in age, but whether they were weathered during Sangamon time or deposited then can only be guessed. In either case the strong red soil development

TABLE 3. CORRELATION CHART

^{14}C DATE*	FORMATION		STRATIGRAPHIC UNIT	SYMBOL	TERRACE	THREE CORRELATION INTERPRETATIONS†			
190 250	PIPPINS		Upper Pippins	P_2	T-0				Holocene
430 820			Lower Pippins	P_1					
1000 1400 1800	RODGERS	Upper	Stratum 4 (G_2)**	R_6	T-1c				
2400			Stratum 4 (G_1)	R_5					
3600 4600			Stratum 4 (G_1)	R_4					
5000		Middle	Stratum 3 (f)	R_3					
6300			Stratum 2 (E)	R_2					
8000		Lower							
10500			Stratum a (A, B, C, D)	R_1					
13600	BONEY SPRING		Boney Spring tusk filling	BS	T-1b	PORT BRUCE			Late Wisc.
16500			Boney Spring bone bed (E) Boney Spring alluvium (D)			Erie NISSOURI			
20500 26400			Trolinger younger peat (e) Boney Spring peat (C_3)			Farmdale	Farmdale	Farmdale	Wisconsin
29300 33000	KOCH		Trolinger older peat (d_3) Koch alluvium	K	T-1a	Plum Point CHERRYTREE	Plum Point	Plum Point	
38000			Koch peat (unit b_2)			Port Talbor II	CHERRYTREE		
			Koch Spring & alluvium			Port Talbot I		Jones upper peat may be redeposited and not represent an interstadial	
			Trolinger alluvium						
35000			Jones upper peat (e_2)				Port Talbot II		
			Jones Spring II			GUILDWOOD	?STADIAL	CHERRYTREE	

	TROLINGER FORMATION	Upper	Trolinger alluvium	T_2	T-2b	St Pierre	Port Talbot I	Port Talbot II	Middle Wisconsin
40000			Jones Peat (C_2)						
49000			Jones Peat (C_1)			NICOLET	GUILDWOOD	? STADIAL	
			Jones Spring I						
			Trolinger alluvium						
37000			Kirby peat			Sangamon	St Pierre	Port Talbot I	
		Lower	Kirby Spring	T_1	T-2a	ILLINOIAN	NICOLET	GUILDWOOD	Early Wisc.
			Trolinger alluvium					NICOLET	
			Bresheears formation	B	T-3	Sangamon			Pre-Wisc.

* In years B.P. and selected from Table 1.
** Unit designations
/ Stadials in upper case, interstadials in lower case

TABLE 4. SEQUENCE OF GEOLOGICAL EVENTS AND VEGETATION CHANGES

	Event	Vegetation*	Approx. age**
1	Deposition of Bresheara formation and incision of meanders by point bar deposition (T-3)		
2a	Degradation and abandonment of T-3		
2b	Lowriver discharge and red soil development		
3a	Increasing discharge		
3b	Cutoff of Bresheara Valley meander		
3c	Organic slough deposits form in south arm, Bresheara Valley		
3d	Vertical accretion of Trolinger formation (T-2a)		
3e	Activation of Kirby Spring		
4a	Formation of peat at Kirby Spring	pine and oak herbaceous prairie	37,000
5a	Vertical accretion of Trolinger formation (T-2b)		
5b	Activation of Jones Spring (I) and possibly Trolinger Spring		
5c	Formation of older lower peat (unit C_1) at Jones Spring	Juniper woodland	48,900
5d	Reduced discharge of Jones Spring		
5e	Formation of younger lower peat (unit C_2) at Jones Spring	pine and oak	40,000
5f	Burial of Jones Spring by Trolinger alluvium (T-2b)		
5g	Reactivation of Jones Spring (II) and formation of upper peat (unit e)		35,000
5h	Burial of Jones Spring by Trolinger alluvium (T-2b)		
6	Degradation, soil formation, and abandonment of T-2		

7a	Vertical accretion of Koch formation (T-1a)		
7b	Activation of Koch Spring and Trolinger Spring		
7c	Formation of peat at Koch Spring (unit b_2)	Pine park land	38,000
7d	Vertical accretion of Koch formation (unit a)		
7e	Formation of peat at Trolinger Spring (unit d_3)	Pine park land	33,200
7f	Continued aggradation of Koch formation, burial of Koch peat		
8a	Reduced discharge of Trolinger Spring and eventual desiccation and soil development		
8b	Degradation and abandonment of Koch Terrace (T-1a)		
9a	Vertical accretion of Boney Spring formation (T-1b)	Spruce forest	26,400 20.500
9b	Activation of Boney Spring, renewed discharge at Trolinger (unit e) and occasional over bank deposition in Breshears Valley (unit f2)		
9c	Burial of Trolinger Spring by Boney Spring alluvium (unit f_2)		
9d	Reduced discharge of Boney Spring (unit E) and accumulation of animal bones around the "eye."		16,500
9e	Accumulation of organic clay over bone bed at Boney Spring, soil development	mixed Spruce and deciduous trees	13,500
10	Degradation and abandonment of Boney Spring Terrace (T-1b)		
11a	Vertical accretion of early Rodgers formation (R_1) (terrace T-1c_1) (Strat. 1)	Oak-hickory	11,000-8,000
11b	Soil development followed by degradation		
11c	Vertical accretion of early Rodgers formation (R_2) (terrace T-1c_2) (Strat. 2)	Oak-hickory	8,000-6,300
11d	Soil development followed by degradation		

11e	Vertical accretion of intermediate Rodgers formation (R_3) (terrace T-lc_3) (Strat. 3 colluvium)		6,000-5,000
11f	Degradation		
11g	Vertical accretion of upper Rodgers formation (R_4) (terrace T-lc_4) (Strat. 4)	Oak-hickory	4,600-2,900
11h	Degradation		
11i	Vertical accretion of upper Rodgers formation (R_5) (terrace (T-lc_5) (Strat. 4)		2,400-1,800
11j	Degradation		
11k	Vertical accretion of upper Rodgers formation (R_6) (terrace T-lc_6) (Strat. 4)		1,400-1,000
12	Degradation and abandonment of Rodgers Terrace (T-1_c)		
13a	Vertical accretion of lower Pippins formation (P_1) (terrace T-0_a)		820-430
13b	Degradation		
13c	Vertical accretion of upper Pippins formation (P2) (terrace T-0_b)		250-190
14	Discharged controlled by Pomme de Terre dam		10-0

*Dominant vegetation from King, 1973; King and Allen, 1977; King and Lindsay, 1976; King and McMillan, 1975.
**Radiocarbon dates in years B.P. (Before Present = 1950) from Table 1.

on Breshears alluvium can logically though tentatively be correlated with the typically red Sangamon soil in well drained sites of the mid-continent. In this case the peat at Kirby Spring would be of early Wisconsinan age and probably correlative with the St. Pierre Interstade (Drimanis and Goldthwaite, 1973), and early Trolinger aggradation would have occurred during the Nicolet Stadial (Terasmae and Dreimanis, 1976).

Erosion of the lower Trolinger formation would have occurred during the St. Pierre Interstadial and perhaps deposition of the upper Trolinger formation began early during the Guildwood maximum if glacial maxima correspond to maximum spring discharges (maximum recharge?) as the Boney Spring example implies. Carrying this interpretation (Table 3, B) further, the rest of Trolinger aggradation would have occurred during Port Talbot time with the Jones peats corresponding to Port Talbot I and II. There is no obvious stadial between these two interstadials to explain the eruption of Jones Spring II unless it is represented by the Dunwich till (Drimanis and Goldthwaite, 1973), but the next significant advance, the Cherrytree Stadial, might correlate with the eruption of Koch spring.

The Koch peat appears to fall within the Plum Point Interstadial and the younger peat at Trolinger Spring partly in the Farmdalian substage. The correlations of the Boney Spring stratigraphy with the Nissouri stadial and subsequent deglaciation is more convincing, as already stated.

While deglaciation was taking place there was a general lowering of water tables in the Ozarks as well as elsewhere. The eventual effect of this was the reduction of soil moisture and seeps on hillslopes with the result that the character of slope soils changed. This change in the substrate for plant growth led to more xeric vegetation and more unstable slope cover. Perhaps this in combination with a climatic change to more intense storms increased slope

erosion and sediment load. Early Rodgers colluvium at the shelter appears to have been partly ablation slabs (ebulee) from the roof presumably because of more intense freeze-thaw activity than at anytime since. This was followed by relatively little colluvial deposition until, during Stratum 2 time, more colluvial dolomite and chert gravel appears in the sediments, and reaches a maximum during Stratum 3, which may represent an alluvial fan or mud flow formed during a short interval. Colluvial processes remained dominant during Stratum 4 time. This sequence appears to reflect increasing slope wash alluviation and hillslope erosion until more bare rock is exposed today than in the past, resulting in more coarse colluvial gravel interbedded with fine grained alluvium.

Brakenridge (1981) suggests that floodplain stability 20,000 to 13,500 B.P. (Boney Spring formation) and 7,500 to 5,000 B.P. (middle Rodgers alluvium) was caused by intensified zonal circulation of the upper atmosphere (Knox, 1976) resulting in less frequent large floods relative to more floods of smaller size (Knox, and others, 1975). The periods referred to are actually times of aggradation of vertical accretion deposits, not stability, which came at the end of the periods. By less frequent large floods he apparently means less overbank deposition. Conceivably this could reduce vertical accretion to a point of stability.

He further suggests that downcutting is caused by intensified meridional circulation resulting in increased stream power (Bull, 1979) and more frequent floods, but the character and size of the floods is not stated. It is well established that overbank floods can either add to or erode the surface of floodplains, but vertical accretion is the net effect of overbank floods.

From the alluvial history of the Pomme de Terre presented here it is clear that degradation has been mostly by bank erosion and not channel deepening. It is conceivable, therefore, that a reduction of effective floods to less than

bankfull stage could result in stability of floodplain aggradation, although erosion of the stream banks would eventually remove large parts of the terraces, especially if the sediment yield from drainage basins has been reduced by prior stripping of the bedrock slopes. Perhaps at this stage lateral accretion would become the predominant fluvial process if most of the top stratum were to be removed, but the evidence shows little time at this stage before the river reverts to an aggradational mode. Under these hypothetical considerations degradation appears to have been produced by lower discharges than was aggradation, a situation not uncommon in arroyos.

Under what circumstances did the regimen reverse and change from degradation to aggradation? Obviously more sediment and more frequent overbank floods are required to build a new floodplain by vertical accretion. Sediment could come from erosion of older terraces and from slopewash. Older terraces have undergone more erosion during the degradational stage than during aggradation so slope wash would appear to be the predominant source. Widespread loess deposition was greatest during the Pleistocene and coincided with glacial advances (Frye and others, 1968). Weathering of bedrock and soils thereon appear to have been a lesser source of slope sediment than loess deposition during the late Quaternary. If loess blanketed the uplands more intense rains would be required to wash it to the streams. The greater the effect of vegetation in protecting slopes, the more intense the storms would have to be to overcome the effect, whether or not they were a response to meridional atmospheric circulation (Knox, 1976). These factors tend to indicate that floodplain aggradation of the Pomme de Terre by vertical accretion during the late Pleistocene was caused by a change to more intensive storms occurring during a time of loess accumulation on adjacent slopes. Aggradation would continue as long as overbank flooding occurred and the slopes yielded sediment but at a diminishing rate as the height of the

floodplain rose and/or as the sediment yield decreased by either stripping to bedrock or growth of more effective vegetative cover (Schumm, 1965).

Applying this reasoning to the Boney Spring formation, there appears to have been stability between 26,000 and 22,000 B.P., the Farmdalion Substage (interstadial). There was net aggradation during the Woodfordian Substage with hydrostatic pressure reaching a maximum sometime before 16,500 B.P. at Boney Spring when the feeder formed. These events indicate that overbank flooding and vertical accretion coincided with increasing hydrostatic pressure on the basal gravel acquifer which indicates that recharge was increasing during glaciation.

Formation of the Boney Spring feeder appears to have coincided within a millennium or so of the Late Wisconsin maximum because by 16,500 discharge had declined and the floodplain remained stable during the Erie Interstadial. Stability continued during the final phases of Late Wisconsin deglaciation until a degradational mode set in between 13,500 and 10,500 B.P. coinciding with the Two Creeks interstadial.

The question arises, did the indicated increased hydrostatic pressure and, therefore, discharge of the Pomme de Terre occur because of increased precipitation or reduced mean annual temperature (Brakenridge, 1978)? The slope washing and overbank flooding would appear to require more than just a decrease in temperature, but this does not necessarily mean there had to be a significant increase in rainfall. A change in rainfall intensity or an increase in the frequency of the more intense storms could produce the result (Knox, 1976).

Unconsidered so far is the relative effects of runoff versus groundwater effluent to stream discharge. Groundwater entering the stream via underwater springs and through the basal gravels will have the same power to erode as runoff without sediment. It appears, therefore, that bank erosion could occur as

a result of groundwater discharge continuing after (lagging) the period of maximum recharge; in other words during the transition from a glacial stade to an interstade. This may have been augmented by a reduction in sediment yield upon a lessening of loessial fallout.

Minimum discharge would be attained through reduced precipitation and/or increased mean annual temperature when groundwater discharge had reached a minimum. Both recorded and oral history shows that the Pomme de Terre ceased to flow for several days twice during droughts of the past 50 years (Brakenridge, 1979). At these times it was an influent stream. If the influent mode became a semi-permanent condition it would require more than reduced mean annual temperature to return the discharge to the proportions indicated by the Pleistocene alluvial terraces and periods of maximum spring discharge. It appears that some degree of increased precipitation is required as well.

The difference in the lithology of late Pleistocene versus Holocene alluviation and cut-and-fill frequency is probably due to several factors, not the least of which is reduced discharge. With the end of glaciation there was a reduction of loess deposition with only a small amount, the Bignell loess (Frye and others, 1968), occurring in the early Holocene and probably coeval with the Great Lakean Substage (Evenson and others, 1976). With diminishing loess deposition during Rodgers time, sediment on the slopes was being removed faster than it was being replenished. The greater deposition rates and the coarser sediment of Rodgers top strata compared to the earlier ones may have been the result of a less effective vegetative filter brought about by the establishment of the deciduous forest and open "glades" during the Holocene.

The increase in the frequency of cut-and-fill cycles during the Holocene is also not clearly understood. As mentioned before, Brakenridge (1980) attributes this to Holocene climatic changes and applies the model of Knox (1976) in

attributing more intense, and therefore erosive, rains to meridional flow of the upper atmospheric circulation pattern as the explanation, but I believe it is equivocal whether the net result would be degradation or vertical accretion along the Pomme de Terre.

Another factor might be human utilization of the floodplains. Natural floodplains were probably covered by dense growths of vegetation that reduced the velocity of overbank flow and promoted sedimentation. Disruption of this cover by fire or artificial clearing would lower the threshold for erosion.

As previously mentioned dispersed charcoal as well as charcoal from archaeological hearths was found in several of the test trenches in Rodgers alluvium and helped establish the radiocarbon chronology. Charcoal and archaeologically-produced chert flakes were found at 2, 6, and 8 m below the surface in Rodgers alluvium at core hole No. 15 at the mouth of the Breshears Valley (Fig. 2). Fires were often deliberately set to clear away brush and other vegetation and to drive game. The earliest evidence of man in the Pomme de Terre Valley is the 10,500 B.P. occupation of Rodgers Shelter by hunters, during aggadation of early Rodgers alluvium (R_1). Foraging continued to be the main subsistence base through the Archaic period during which 5 erosional expisodes occurred which may have been triggered by floodplain fires during periods of climatic stress and less overbank deposition such that stream power exceeded the lowered threshold for net erosion. By late Archaic time agriculture was practiced at the Phillips Spring site (Kay and others, 1980) and thereafter the clearing of floodplain land for farming probably increased, further lowering the threshold for erosion. Charcoal is even more abundant in Pippins alluvium suggesting more intensive human use of floodplains.

Conclusions

The once meandering ancestral Pomme de Terre River has, since perhaps Sangamon time, undergone at least four major cycles of degradation and vertical accretion represented by four terraces confined to its valley incised into cherty Ordovician dolomites. During Holocene time there have been eight epicycles of cutting and filling. Chert gravels underlying all of the vertical accretion deposits may be relict lateral accretion deposits that are reactivated at flood stage only when they coincide with the active channel where they form pools and riffles. The basal gravels form an acquifer feeding several artesian springs that have erupted to the surface of floodplains at times of high hydrostatic pressure that appear to correlate with glacial maxima. Aggradation appears to take place under mesic conditions coinciding with glacial advance in more northerly regions, and stability with the onset of deglaciation. Peat deposits over spring conduits and feeders reflect reduced discharge and contain pollen, plant remains, and animal bones indicating less mesic interstadial conditions.

Sediment yield accompanying aggradation may be from loess derived from glacial outwash elsewhere and washed from slopes in the drainage basin. Slope vegetation acted as a filter on slope wash allowing finer fractions of sediment to charge the streams. Vertical accretion occurred during periods when overbank floods caused net aggradation. Degradation occurred by bank erosion during times of reduced overbank flooding.

Generally coarser Holocene alluvium may have been due to less effective vegetative filtering as well as the reduction of loess deposition and slope washing of the coarser fractions left after the Pleistocene winnowing of fines. Causes of the increased frequency of cut-and-fill epicycles during the Holocene could have been due to a combination of factors such as increased frequency of intense storms, reduced sediment yield from increased denudation of bedrock

slopes, and reduction of floodplain vegetation by human activity. For whatever reason there is an approximate correlation between these epicycles in the Ozark Highlands and the western United States. At least for the early Holocene there appears to be approximate correlation to the few documented sequences in the east (Coe, 1964; Gardner, 1977) and midwest (Butzer, 1977; Knox, et. al., 1975).

As in many other stream valleys in the United States there is a marked difference in the color, texture, and amount of late Pleistocene alluvium compared to Holocene alluvium, and a pronounced interval of degradation, occurring between 13,000 and 11,000 B.P., separates them.

Paleoindians first appear at Rodgers shelter 10,500 years ago and the occurrence of a few fluted point surface finds indicates occupation of the Pomme de Terre area as early as 11,000 B.P. In spite of more abundant plants and game animals there is no evidence of man before this. Because of Koch's claim for the association of artifacts with mastodon bones and because we were scientifically excavating deposits with the best possible prospects of having Paleoindian artifacts, all personnel involved over 14 consecutive field seasons were constantly on the lookout for artifacts in situ in the pre-Rodgers sediments (Wood, 1976). None were found.

This project provided an excellent opportunity to study the complex stratigraphy of alluvial springs and to compare these to others in the western United States such as Tule Springs, Nevada (Haynes, 1965), V. P. Mammoth rite, Wyoming (Haynes, n.d.), Blockwater Draw, New Mexico (Haynes and Agogino, 196), and Murray Springs, Arizona (Haynes,). The sand feeders are common to all of these, but the Pomme de Terre springs are the only ones in my experience with the concentric conduit gravels. Basal alluvial gravels are common to all of the Pomme de Terre springs but, of the western examples, only to those at the type Clovis site in Blackwater Draw. These may not have developed concentric

conduit gravels because of 1) The lack of sufficient hydrostatic pressure in the relatively flat terrain or 2) the consolidation (calichification) of the overlying strata or 3) possibly the rapid tectonic formation of a fissure.

A common factor in all of these late Pleistocene springs is the death and preservation of the remains of Rancholabrean "big game" animals. Only the youngest of these, post dating 12,000 B.P., have evidence of human predation.

In spite of possibly more detailed data on late Quaternary chronostratigraphy than anywhere else in the unglaciated mid-continent we still do not have enough pertinent facts about the interrelationships of climate, vegetation, and fluvial processes on the lower Pomme de Terre to make these conclusions any more than working hypothesis. Perhaps further understanding could be had by modeling the Pomme de Terre fluvial systems, a step I hope someone will pursue. In the meantime, about 30 additional radiocarbon samples are being processed that will hopefully provide a more precise chronology for the mid-Wisconsin part of the succession.

Late Quaternary stratigraphic investigations in the Ozark Highland and eastern United States are seriously hampered by the dense vegetative cover compared to the western part of the country because natural exposures are limited and commonly inadequate. Core data is a help but mostly in testing questions raised by stratigraphic mapping from artificial excavations. The backhoe is undoubtedly the most useful tool yet devised for stratigraphic mapping of alluvium, but it can be deadly, especially where shallow ground water is reached. The best policy in such circumstances is to remove one wall of the trench. Bracing of walls with stulls, cribbing, etc. is unsatisfactory because such measures are not only time consuming and very inconvenient but are likely to hide the often subtle contacts one is looking for.

Since impoundment in 1978 fluvial processes are no longer active along the lower Pomme de Terre. Instead we can look forward to gradual sedimentation of the Harry S. Truman Lake by deltaic accretion and lacustrine muds until a time when future generations find they have a giant mudflat. This might once again bring agriculture to the lower Pomme de Terre to help feed what might then be an overpopulated world of hungry people.

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PART III

ENVIRONMENTAL STUDIES

NUMBER 2.

ASPECTS OF THE SOIL GEOMORPHOLOGY OF THE LOWER POMME DE TERRE RIVER VALLEY, MISSOURI, AND SURROUNDING REGION

by

Donald Lee Johnson,
Donna Watson-Stegner,
and Peter R. Wilcock

Preface*

I was first introduced to the Pomme de Terre valley in 1967 when as a fresh graduate student at the University of Kansas an archaeologist friend of mine, Dennis Yaple, invited me to visit Rodgers Shelter. At the time, Yaple was working as a "shovel hand" for Bruce McMillan, who was excavating the shelter as part of his dissertation research. I seized the opportunity to bring along my "soil geomorphology field kit" to gain some experience in practicing soil and sediment analysis, my chosen area of research. The occasion proved to be most fortuitous for me, as I soon made my first soil-geomorphic discovery at Rodgers Shelter during a south to north (river to shelter) chemical transect. I encountered an abrupt rise in pH and reaction precisely at the point directly below and inside the dripline of the shelter overhang. The sediment was leached outside the dripline, calcareous within it (not surprising, really, but at the time I was very impressed). Further, this visit to Rodgers Shelter, and later ones, afforded me the opportunity to meet Bob Brakenridge, Steve Chomko, Vance Haynes, Ann Johnson, Jim and Fran King, Everette Lindsay, Bruce McMillan, Pete Mehringer, Donna Roper, Jeff Saunders, Ray Wood, and a number of other investigators. Most of these individuals have, over the years since, become very good and trusted friends and professional colleagues whom I greatly value.

In 1975 I was encouraged by Ray Wood to propose soil geomorphic work on the Truman Reservoir Project for the purpose of interfacing basic pedology concepts with those of archaeology, geology, and other studies then being conducted or proposed. I jumped at the challenge - for here was an opportunity to study alluvial soil development and alluvial soil geomorphology in an area that had good geologic, archaeological, paleoecological, and chronologic control, with prospects of even better control as work progressed. Few localities can offer such advantages in pedologic studies.

As research got underway I introduced three of my students to the soil geomorphologic aspects of the Truman Reservoir project; Mike Miller, Donna Watson Stegner and Pete Wilcock. During the course of the project the four of us have gained invaluable experiences and have shared in many exciting discoveries and in developing new concepts and principles in pedology and soil geomorphology. This work and spin-off research has resulted in a master's thesis (Watson-Stegner 1980a), a Ph.D. thesis (Miller 1982), and a number of papers soon to be published that were read at various national and regional professional meetings (Appendix A).

Finally, we are pleased that our collective research efforts reported here have contributed to the overall understanding of the paleoecologic and cultural environment of the Truman Reservoir Project, to the Ozarks and Midwest region in general, and to soil genesis theory and principles of pedology and soil geomorphology.

*Written by the senior author

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So many people have contributed to this research in one way or another that it is, alas, almost inevitable that somebody will inadvertently be overlooked. To those, I humbly apologize. Be that as it may, I greatly appreciate the help of the following individuals: Jim Bier, Cynthia Bonkiewicz, Barbara Bonnell, Bob Brakenridge, Herb Glass, Vance Haynes, Ivan Jansen, Ann Johnson, Diana Johnson, Christina Pheley, Donna Roper, Ed Runge, Timothy Saunders, Janeen and Frank Smith, Steve Stegner, and, of course, my three able assistants and colleagues, Mike Miller, Donna Watson-Stegner, and Pete Wilcock.

The help of the following institutions and/or departments are also acknowledged: Departments of Agronomy, Geography, and Geology, University of Illinois, and the Illinois State Geological Survey. Appreciation is, of course, also extended to the University of Missouri, and the Army Corps of Engineers for funding the research presented herein.

*By the senior author

Chapter One

INTRODUCTION

Soil Geomorphology, Soilscape Palimpsests, and Soil Development Models

Soil geomorphology is an interdisciplinary science which melds the principles of pedology, physical geography, Quaternary geology, and geomorphology in interpreting present and past landscapes. A genetic assessment of exposed or buried geomorphic surfaces in terms of their age, evolution, and relationship to other surfaces (i.e., their correlation) is a principal goal of practitioners of this young but rapidly growing science.

Soil is the thin, normally unconsolidated layer of minerals and organic matter which serves as the "skin," or epidermal layer of landforms and thus is an integral part of them. Hence, the expression "soil geomorphology." In an areal or spatial sense this epidermal layer is a soilscape that is a storehouse of paleoenvironmental and other information, which if properly deciphered yields very fruitful genetic interpretations in pedology, geomorphology, Quaternary geology, archaeology, and related sciences such as geochronology. A soilscape may, in this sense, be thought of as a palimpsest, which retains a record (oftentimes blurred) of imprinted processes, factors, and events.

Because interpreting the age and evolution of soilscape palimpsests and deciphering their environmental "meaning" is such an important part of soil geomorphological research, soil geomorphologists are very much interested in the processes and factors of soil formation. Hence, the nuances of soil genesis are of fundamental importance in soil geomorphology, as are conceptual models of soil genesis.

Most soils in the midlatitudes are organized more or less into horizontal layers or horizons which lie approximately parallel to the surface, and differ from one another in physical and/or chemical properties. A vertical section from the surface down to the unweathered parent material or unweathered bedrock below the soil is called the soil profile. The characteristics of the profile determine how the soil will be classified, and generally reflect what processes and factors have produced it.

Soil development and formation consists of several steps - the accumulation of parent material followed by differentiation of a profile often (though not always) with recognizable horizons. The soil development process occurs when materials are added to or removed from the soil, when soil constituents are moved from one depth to another, or when substances in the soil are chemically transformed (Simonson 1959). For example, in many soils, clay, suspended in water, is moved from the upper soil ('A' horizon) and deposited at some depth ('B' horizon), creating a profile with a textural difference between A and B horizons. These processes may be expressed in the following model as:

$$S = f(a,r,t_1 t_2) \qquad (1)$$

where S, is soil, a additions, r removals, t_1 translocations, and t_2 transformations.

Soil formation may also be viewed as the sum of two sets of coacting processes, those that promote horizonation and those that promote homogenation, or mixing (Johnson and Watson-Stegner 1981; Johnson n.d.; Wood and Johnson 1978; Hole 1961). These two sets of processes may be expressed in the following model as:

$$S = f(h_1, h_2) \tag{2}$$

where S is soil, h_1 is the set of processes which cause horizonation—the organizing or banding vector, and h_2 the set of processes which cause homogenation—the turbulence or blending vector. Neither of these two sets of processes is mutually exclusive, and both are always operating simultaneously in the same profile or horizon but usually (though not always) one is more predominant than the other. Unhorizonated Vertisols, for example, are dominantly an expression of h_2 vectors, and horizonated Alfisols of h_1 vectors. One strength of this model is that it juxtaposes pedoturbation (which occurs in varying degrees in all soils) and horizonation processes at similar levels of pedogenic importance, a conceptual emphasis lacking in other models. Inclusion of this model in the conceptual repertoire of soil geomorphologists expands their interpretive options in the complicated task of unravelling the palimpsest threads of soilscape evolution. It is also one method of explaining how soils that possess youthful developmental features can occur on geomorphic surfaces that are demonstrably old.

The most familiar model of soil formation was proposed by Russian pedologists and translated into English by Marbut via German by Glinka, with amplification by Jenny (1941, 1980). It states that soil formation reflects joint but independent local influences of five factors—climate (cl), organisms (o), relief (r), parent material (p), and time (t):

$$S = f(cl, o, r, p, t) \tag{3}$$

In utilizing this model in soil geomorphic work, the time factor is critical, for it is widely assumed that the degree of horizon formation and soil development increases over time until a near steady state is reached, if all other factors are constant (Birkeland 1974). It is a widely used model, and useful in soil geomorphologic research.

Another model, essentially a simplified version of Jenny's model, is one less well known and was developed by Runge (1973). It states that the most important elements of soil development, at least in midlatitudes, are the amount of organic matter added (the retarding vector), the amount of water infiltrating the soil and affecting horizonation (the organizing vector), and time:

$$S = f(o, w, t) \tag{4}$$

where o = organic matter, w = water, and t = time. In simplest terms, this model states that soils high in organic matter (other things equal) will be minimally developed, and soils with abundant water passing through them (other things equal) will be maximally developed (minimal development = indistinct and thin horizons, dull colors, little illuvial clay; maximal development = distinct and thick horizons, bright colors, much illuvial clay). Organic matter is thought to be the retarding vector because it acts as paint on mineral grains to limit weathering of the grains and, hence, clay formation. Water is the organizing vector because it moves clay from the A to B horizon,

and promotes weathering, and, hence, clay formation. This model is referred to as an energy model, where the soil may be thought of as loosely analogous to a chromatographic column. Its greatest utility is that it emphasizes the energy of moving water as the principal organizing vector in soil formation. Although this model is new, and has drawn criticism (Yaalon 1975), probably deservedly to some extent, it has recently been positively tested in the Truman Reservoir area and shown to have valuable utility under certain circumstances (Watson-Stegner 1980a, 1980b, and this report).

The significance of both Jenny's and Runge's models is that strongly expressed and well developed profiles (i.e., those that appear to be old) may be due indeed to age (the factor "t" in equations 1 and 2), or to energy (the factor "w" in equation 2), or to both age and energy ("t" and "w"). However, while recognizing that the energy model has great utility in some instances, unless energy relations are suspected it is otherwise generally assumed in soil geomorphological work that a reddish, well ordered and developed profile with strong and distinctive horizons is chiefly a reflection of time.

No one of the four models outlined above is necessarily better than the others, but in any given profile one may prove more useful in deciphering the soilscape palimpsest (though all should be carefully weighed and conceptually consulted in the soil examination process).

Using the above body of assumptions, concepts, and information, soil geomorphologic work was carried out in the Truman Reservoir area.

Scope of Work

Several important questions raised in part by the previous work and partly through intercommunications with co-workers on the project served as the nucleus of research designs and execution strategies for this study. One central question deals with the ultimate source of the silt which dominates the Holocene-aged alluvium of the Osage River Basin. How much loess, if any, has contributed to soil parent materials in the area, and is the Rodgers alluvium largely redeposited loess stripped from the valley sidewalls and interfluves in post-glacial time? What are the ages and origins of the Rodgers and Pippins alluviums, and why is the former light brownish in color and the latter dark brownish (blackish)? These questions are taken up in Chapter 2.

Another question concerned the differences in soils developed on the Rodgers alluvium, which range from Inceptisols (weakly to moderately developed soils) to Alfisols (moderately to strongly developed soils). Why such developmental differences in soils formed in parent materials of essentially the same age? Our previous soil mapping work revealed several consistent soil patterns, one being that strongly developed soils[1] (Albaqualfs) on the Rodgers alluvium seemed invariably to occur at or near springs and at the base of slopes where water collected. Would Runge's energy model explain the pattern? These questions are taken up in Chapter 3.

[1]In this report, the phrases "strong development" and "strongly expressed soils" refer to well horizonated soils that are texturally differentiated (i.e., presence of an argillic horizon) often abruptly, with leached A_2 (eluvial) horizons.

Two other important questions raised by the earlier soil mapping project are, why are incipiently developed buried soils, inferred on theoretical grounds to be present on any episodically accreting alluvial unit, not apparent in the Rodgers alluvium (away from valley sidewalls) since it was deposited intermittently over an 8,000-9,000 year period? Secondly, why do some soils show certain attributes of strong development (e.g., inordinately thick (1-3 mm) clay skins at 2-4 m depth but which are only incipiently developed in the $B_{2}t$ horizons where most illuviation (clay deposition) occurs? These questions are also taken up in Chapter 3.

Finally, what are the prospects of applying the soil geomorphologic relationships established in this study to other areas of the Ozarks, and the Midwest in general? Can these relationships be used in predicting early (paleo-Indian), middle (Archaic) and late (woodland) sites in the region? These questions are considered in Chapter 4, the concluding chapters, along with suggested further work.

All the above questions formed the essential core of the scope and purpose of the research carried out.

Limitations

The results of research presented here represents a tremendous amount of collective work on the part of the writer and colleagues. To the extent originally outlined in the proposed soil geomorphic work on the Truman Reservoir Project, our initial goals have been realized considerably beyond expectations. By the same token, our interests and research involvements have expanded considerably beyond the originally proposed work. Thus , it must be emphasized that the research presented here is a summation of work to date, some of which is still continuing. For example, mineralogical studies of silt and clay fractions in the loess study (Chapter 2), plus refinements of concluded work, are continuing as of this writing and will most likely continue for a number of years as time permits. This may be considered "icing" on an otherwise thick cake.

Further, several new localities beyond the originally proposed work have been studied, and where they relate to the Truman Reservoir Project they are included (more "icing"). Because it was incomplete as of this writing, the work of M. Miller (Ph.D. thesis) was not included here (it will be available in early 1982 through inter-university inter-library loan services).

Justification

The work carried out by the writer and colleagues complements the work of other disciplinarians involved in the Truman Reservoir Project. The soil and geomorphic components of the overall research project are significant elements in understanding the evolution of the Pomme de Terre soilscape palimpsest and, in the larger context, the Osage Basin landscape in general. Because the landscape is the stage on which human culture evolves, and with which it interfaces, it is thus highly important from that standpoint.

Further, the work carried out by the writer and his colleagues, plus interface work carried out by other disciplinarians involved in the Truman Reservoir Project have provided an unparalleled opportunity to broaden the

basic concepts and principles of pedology and geomorphology. Aside from its own pure science merit, such fundamental soil and geomorphic information will greatly strength archaeological, geological, and paleoecological interpretations in and out of the study area.

Finally, two fundamental goals of science are to seek useful generalizations, and to develop predictive models; the research presented here should allow the realization of both.

Appendices

Appendix A contains a list of papers read at professional meetings, papers published, papers submitted for publication, papers in preparation, and theses that were produced as an outgrowth of this research project.

Appendix B contains particulars and core descriptions of the sediments analyzed for the loess study.

Appendix C contains tables, profile descriptions and other data that deal with the Avery Bridge study area.

Appendix D contains the profile descriptions of the soils exposed in trenches 78B and 78C (of Haynes 1981).

Appendix E contains profile descriptions and laboratory data of the two Montgomery Site profiles, Sac River, Cedar County, Missouri.

Chapter Two

ORIGIN OF SILT IN THE OSAGE RIVER BASIN AND OZARKS REGION

Chapter Content

This chapter examines the origin and age of the silt fractions of the alluvial and other sediments of Holocene age in and around lower Pomme de Terre Valley in particular, and the Truman Reservoir and Ozarks region in general. The focus here is principally on the results of a north-south loess transect, where cores were taken from the Missouri River to a point south of Wheatland. The age and origin of the Rodgers and Pippins alluviums is assessed, as is the origin of their respective brownish and blackish colors. Additionally, the occurrence of silt-dominated alluvium at other sites state-wide and beyond is discussed in the context of the origin of the silt fraction of the Rodgers and Pippins alluvial units.

Introduction

Work done by a number of investigators over the past two decades has revealed the existence of two alluvial units of Holocene age, the Pippins alluvium and the Rodgers alluvium (Haynes 1976, 1981). On the basis of much study, mapping, numerous C-14 dates, and contained archaeology, the age of the Pippins alluvium has been estimated to range from about 1500 RYBP[2] to the present, and the Rodgers alluvium from about 10,500 to 1500 RYBP (Haynes 1981; Kay 1980). While both alluviums are visually, physically and chemically quite distinct, both contain appreciable amounts of silt in the fine fraction.

In light of the above, practically every researcher the writer knows who has worked with sediments and soils in the area asks the same obvious questions: Is the silt fraction of the Osage Basin alluvium dominantly reworked loess which blanketed the study area? (Ahler [1973b,1976] suggested as much, as do Brackenridge [1979, 1980] and Haynes [1981]). If so, what is its origin and age? A related question asked by some of us is: Why is the Rodgers alluvium so characteristically light brownish, and the Pippins alluvium so dark brownish blackish in color? Part of our research strategies in the loess-study phase of the project were organized so as to shed light on, and hopefully answer, these questions.

Methods of Study

A literature search was first conducted to see if other workers had contributed to the problem. They had, and Figure 1 shows a map of Missouri loess deposits adapted from Oetking and others (1966), McCracken (1961), Stout and Hoffman (1973), Thorp and others (1952), and Ebens and Connor (1980). Figure 1 shows that on the basis of these studies up to 1.2 m of loess is estimated to have blanketed the lower Pomme de Terre valley. The loess dispersion model, based on empirical and theoretical data, is shown in Figure 2, and generally accords with Stoke's law.

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[2] Radiocarbon years before present.

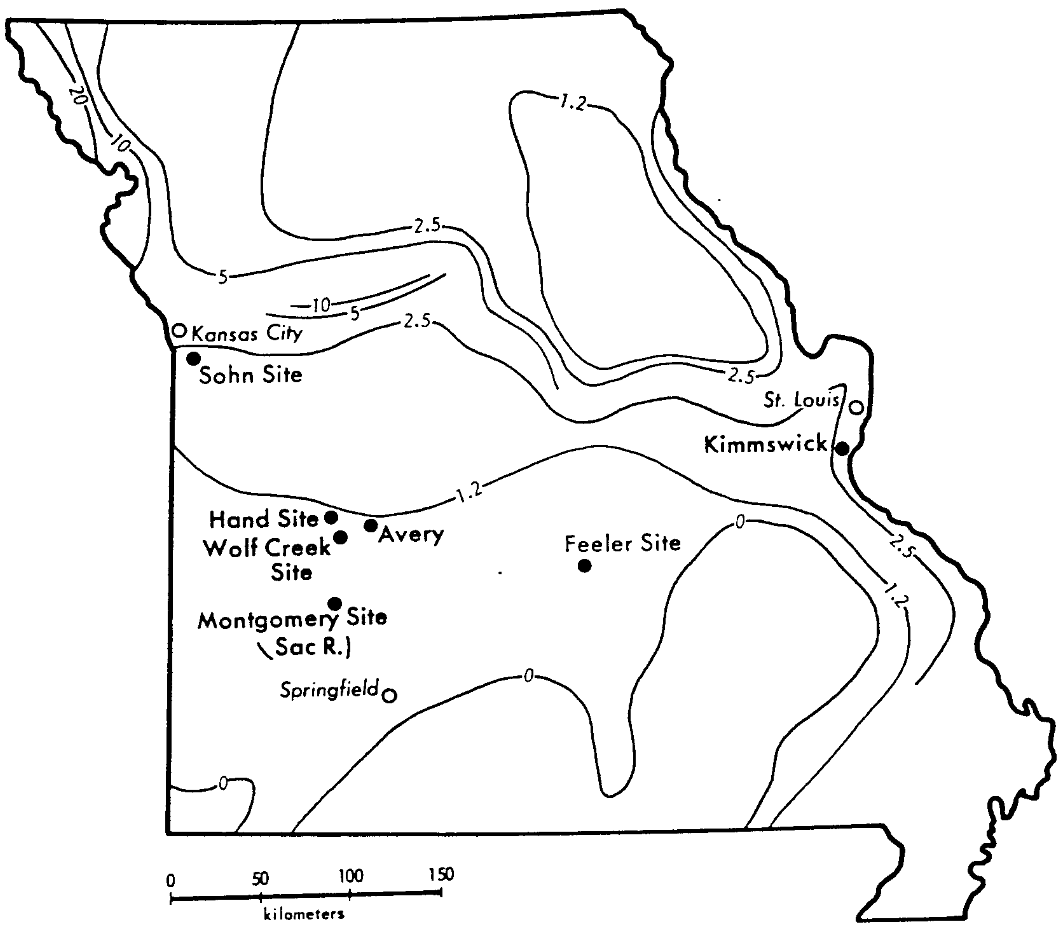

Figure 1. Inferred thicknesses of loess in Missouri. (Modified and adapted from Ebens and Connor 1980, McCracken 1961, Oetking and others 1966, Stout and Hoffman 1973, and Thorp and others 1952.) However, we are of the opinion, based on observations and studies to the south of Missouri in Arkansas and Oklahoma, that some loess covers the entire area, and that the zero (0) isoline line is in error.

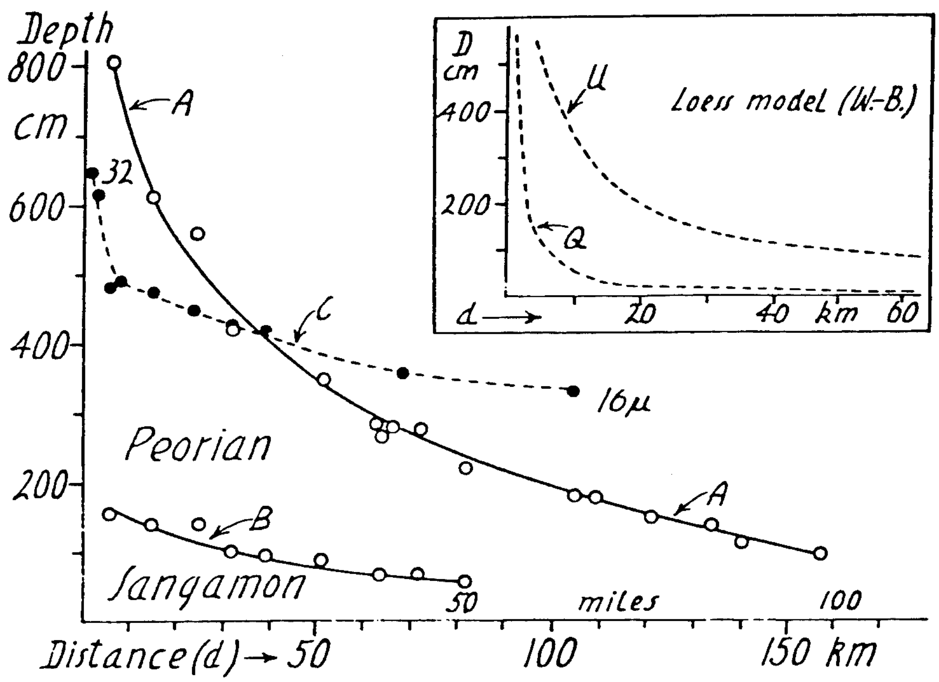

Figure 2. Loess dispersion model showing depth of loess versus distance, based on traverse I of Smith (1942) from river bluff to the lee. Curve A: thickness of loess sheet; B: thickness of buried Sangamon loess; C: mean particle size decreasing from 32 to 16.4μ. Inset: loess dispersion model of Waggoner and Bingham (1961) based on air turbulence theory. (Adapted from Jenny 1980).

To get a further handle on the possible loess input to the soils and sediments of the study area, the writer and P. Wilcock made a 146 km north-south coring transect beginning at the Missouri River, the presumed loess source, near the town of Waverly to a point several km south of Wheatland (Figure 3). A total of 14 undisturbed cores 5.7 cm (2¼ inches) in diameter were pulled with a trunk-mounted hydraulic Giddings rig. The coring localities are termed MLT-1, MLT-2, etc., and were selected because they occurred on relatively flat interfluves that appeared to be stable geomorphic surfaces with less than 2 percent slopes (except Lost Hill, MLT-11, which has 3-5 percent slopes). Difficulty in locating sampling sites was encountered in the Warsaw area, where stable surfaces are rare due to the dissected, high local relief caused by the Osage River. This sampling gap, which we came to call "the Warsaw gap," is apparent on Figure 3. by very shallow coring depths.

Depth of coring along the transect was determined by the depth limits of the Giddings rig (6.1 m maximum), or by penetrating to depth of refusal (bedrock, or other resistant substrate).

Extracted cores were placed in trays, wrapped in Saran, and transported to the Soil Geomorphology Laboratory at the University of Illinois. Once there, cores were briefly described and cut into 10 cm increments (0-10, 10-20, etc.) which were bagged and stored.

Particle size analysis (pipette method) was done on all 14 profiles at 20 cm increments by analyzing the contents of every other bag (always starting at the surface, i.e. 0-10, 20-30, 40-50, etc.). Pretreatments followed standard practices (i.e., H_2O_2 digestion with heat, overnight shaking, sand removal by sieving, etc. - SCS, 1967; no carbonates were encountered in any sample). Three pipettings were taken on each sample to determine four size fractions, coarse silt (50-20μ), medium silt (20-5μ), fine silt (5-2μ) and clay (<2μ). Particle size data were calculated on both a fine earth basis (sand + CSi + MSi + FSi + clay = 100) and clay-free basis (sand + CSi + MSi + FSi = 100). The fine earth data represent the entire sample and are useful in examining pedogenesis, whereas the clay-free data are more useful in parent material analysis and for examining changes in loess particle size with distance from the source.

Mineralogical analyses of the 14 samples were also initiated and consisted of size fractionating the silt from the 10-20 depth increments of each of the 14 sampled cores, and the last depth increments of MLT-7 through 14. To this end, 20 g samples were pretreated as above, and separted from the sand fraction by sieving through a 50 μ sieve (the sand was dried, weighed and stored). The remaining suspension (silt + clay) was then passed through an elutriator designed to fractionate silts at 50-32, 32-16, 16-8, and <8 microns (Follmer and Beavers 1971). The latter fraction passed completely through the elutriator and was concentrated by a suction filtering apparatus using ceramic filter candles, then centrifuged to isolate the 8-2 μ fraction. The suspended clay remaining after centrifugation was sedimented onto glass slides. The four silt fractions of each sample were dried, weighed, and stored for x-ray mineralogical analyses. X-ray analyses was done on a Rigaku diffractometer at 35 KV, 15 ma, $2^{\circ}\theta$/minute scan speed, with Cu Kα radiation.

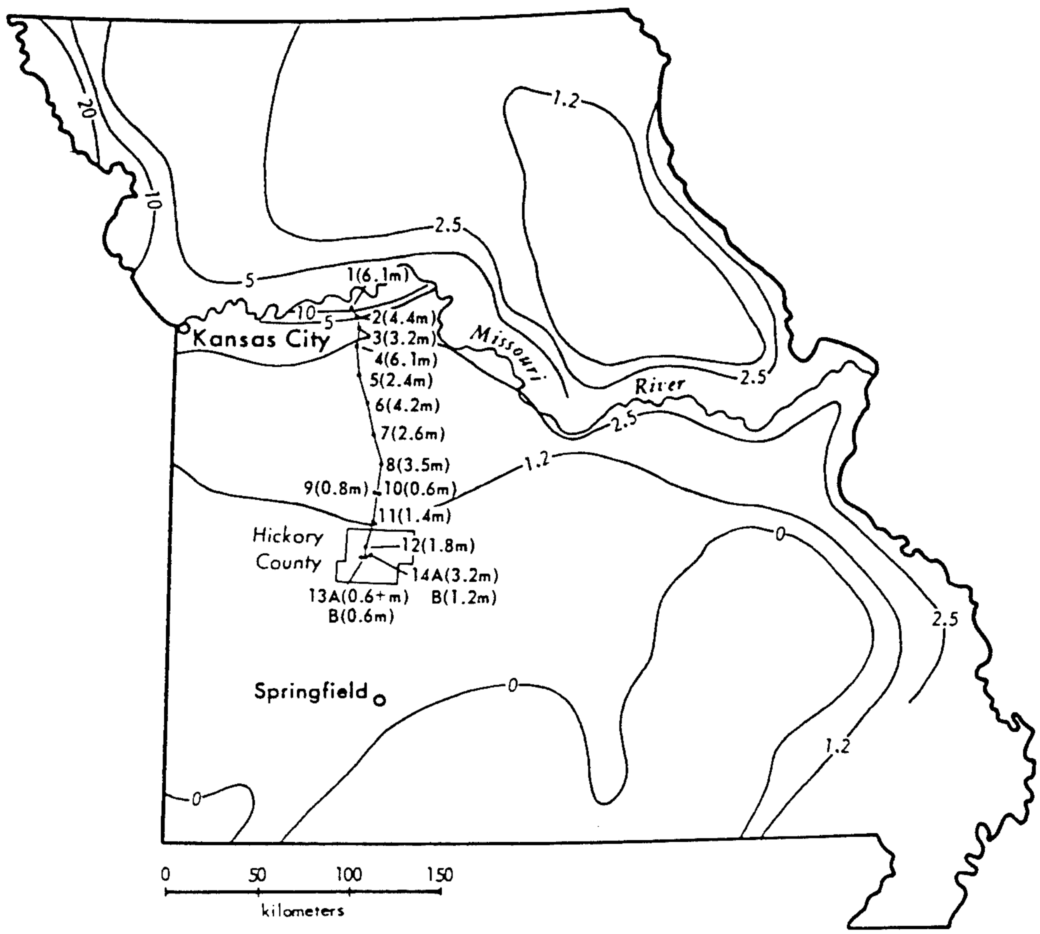

Figure 3. Loess transect undertaken for this study, from near Waverly, Missouri, to a point several km south of Wheatland, Missouri. Precise geographic coordinates of coring sites and other particulars are given in Appendix B. First number at coring sites (dots) is core number; number in parenthesis is depth of core.

Results

Brief descriptions of the 14 extracted cores are given in Appendix B. Sampling locations were as shown in Figure 3. The calculated pipetted fine earth fractions (sand + CSi + MSi + FSi + clay = 100) are presented in cumulative fashion in Figure 4. Calculated pipetted clay-free fractions (sand + CSi + MSi + FSi = 100) are presented in non-cumulative fashion in Figure 5. Particulars of laboratory analyses are also given in Appendix B. Summation of data, including distance from Missouri River, depth of loess/silt mantle, portion of mantle used for calculations, number of samples, and calculated percents of fractionated and total mean clay-free silts is given in Table 1.

The elutriated silt fractions and sedimented clay slides are undergoing x-ray analysis at this writing, so that the results are not included.

Discussion

As indicated, studies by other workers in Missouri have concluded that a meter or more of loess has fallen in much of the Osage River Basin (Fig. 1). Also as noted earlier, it is presumed that the principal source of the loess was the Missouri River to the north.

Loess is a silty mantle that changes in thickness, particle size, and expression of soil development with distance from the source. More specifically, the thickness and particle size of loess decreases with increasing distance from the source. This is shown in Figure 6 where the mean clay-free silt is plotted against log of miles along the north-south transect. Surface soils are better expressed and more developed with increasing distance from the source. With regard to the latter, however, if the loess blanket was thin at any given point it may be incorporated within the residual solum by pedoturbation and be masked. Blurring might also occur if loess deposition were slow enough to allow pedogenetic processes to keep up with, and thus incorporate, eolian infall.

One of the more diagnostic indicators of a loess mantle is that there is a distinct increase in particle size at depth, from silt to sand, for example, indicating a change from eolian to other parent material. It also seems reasonable that the mineralogy of loess would be different from the underlying residual soil that it buried. It must be kept in mind, however, that the normal processes of pedoturbation would most likely blur any loess-residuum boundary unless the loess was thick and deposited rapidly.

A few comments about the graphed data of Figures 4 and 5 are in order. As mentioned earlier, the fine earth data, which includes clay (Fig. 4), are useful in examining pedogenesis (i.e., textural B horizons), whereas clay-free data are more useful for parent material analysis and particle size versus distance from source. Use of clay-free data requires an implicit assumption that silt and sand are the reactants in the parent material whereas clay is the product (of weathering). This assumption obviously eliminates the presence of clay in the original loess parent material, which is an error. More accurately, calculation of clay-free particle size data is simply a means of "cleaning up" the information one has, giving a clearer picture of some areas of information at the expense of others. With the above information in mind, it is instructive to examine the 14 profiles of the transect.

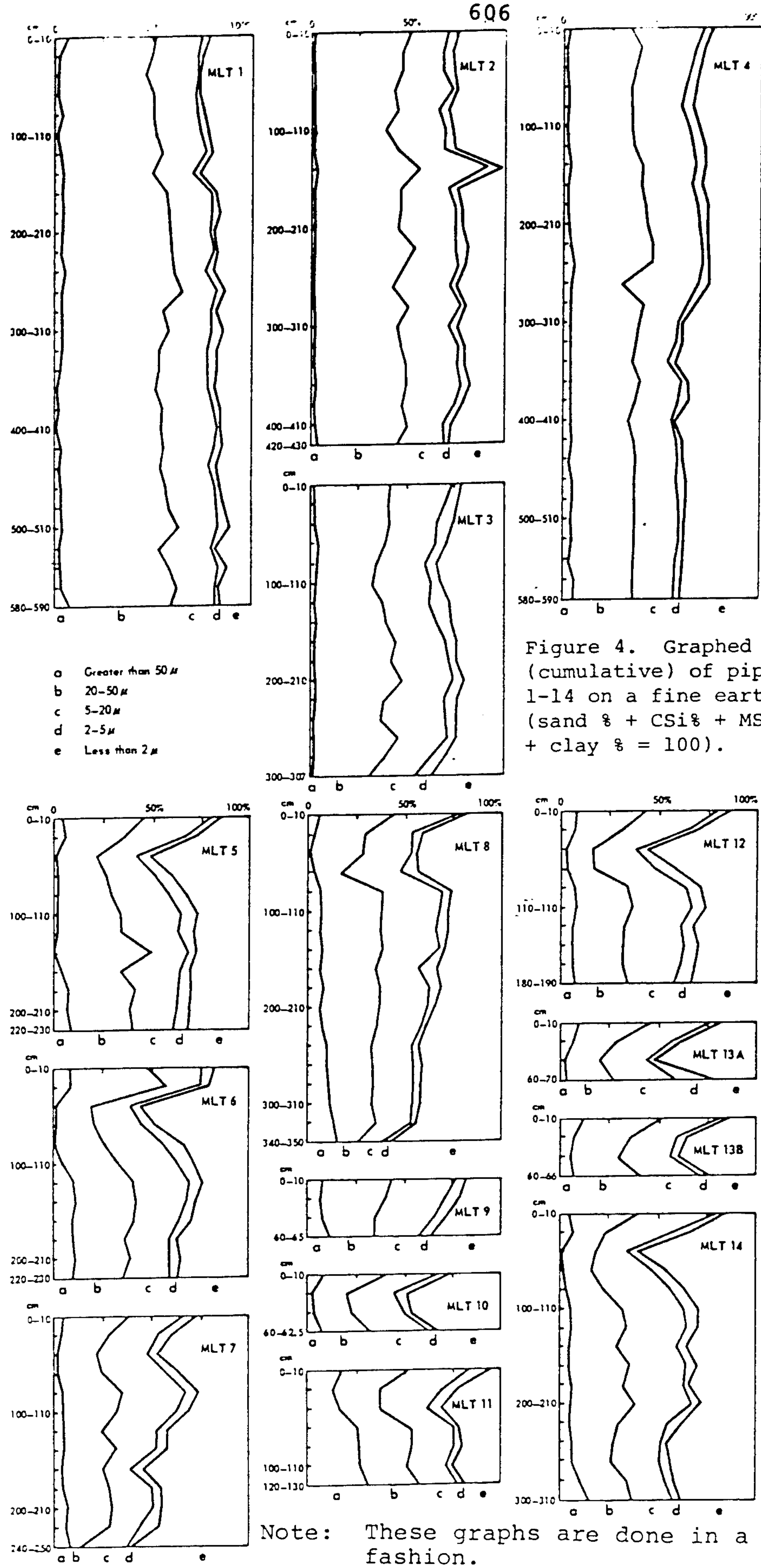

Figure 4. Graphed results (cumulative) of pipetting MLT 1-14 on a fine earth basis (sand % + CSi% + MSi% + FSi% + clay % = 100).

Note: These graphs are done in a <u>cumulative</u> fashion.

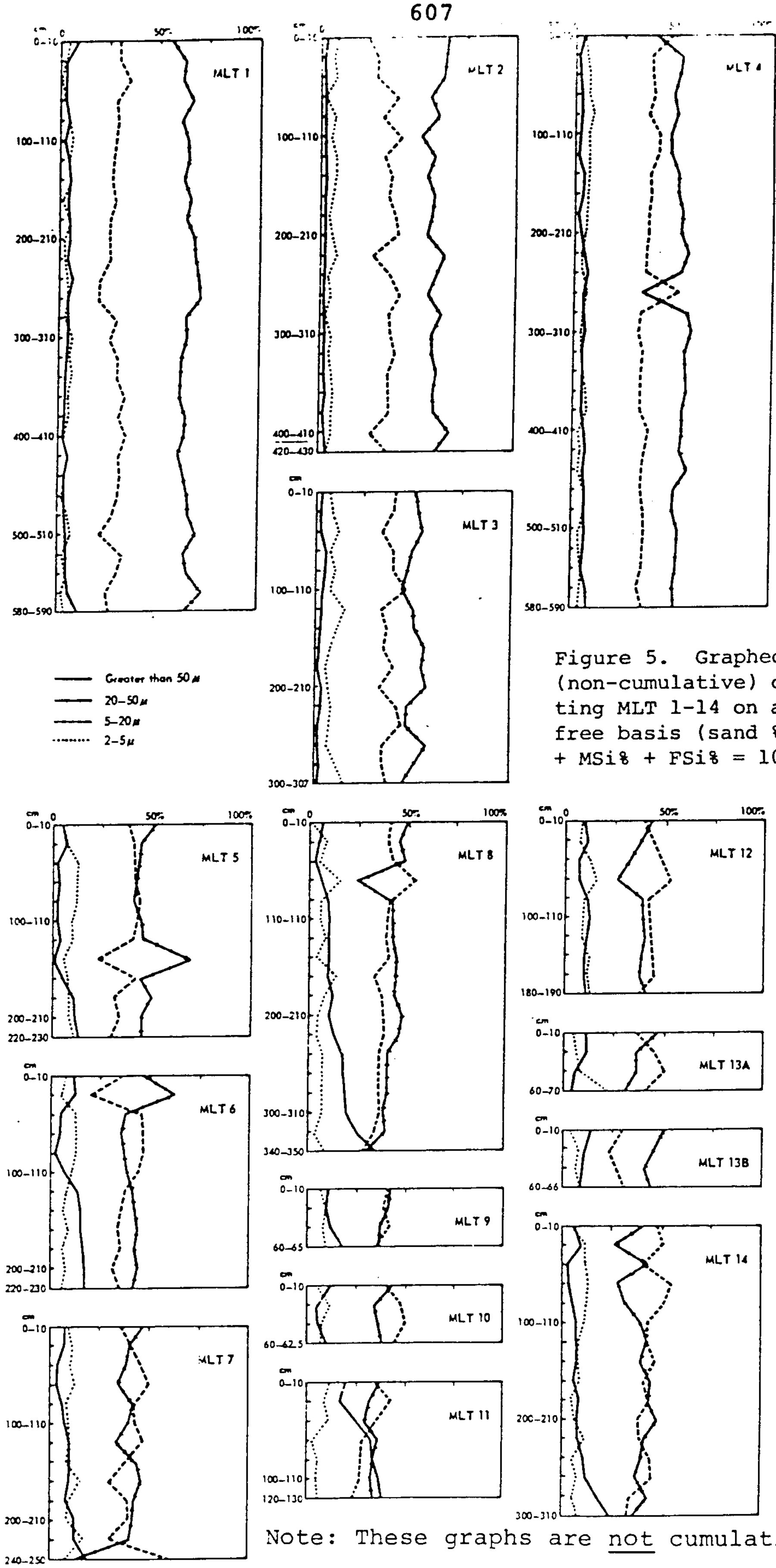

Figure 5. Graphed results (non-cumulative) of pipetting MLT 1-14 on a clay-free basis (sand % + CSi% + MSi% + FSi% = 100).

Note: These graphs are <u>not</u> cumulative.

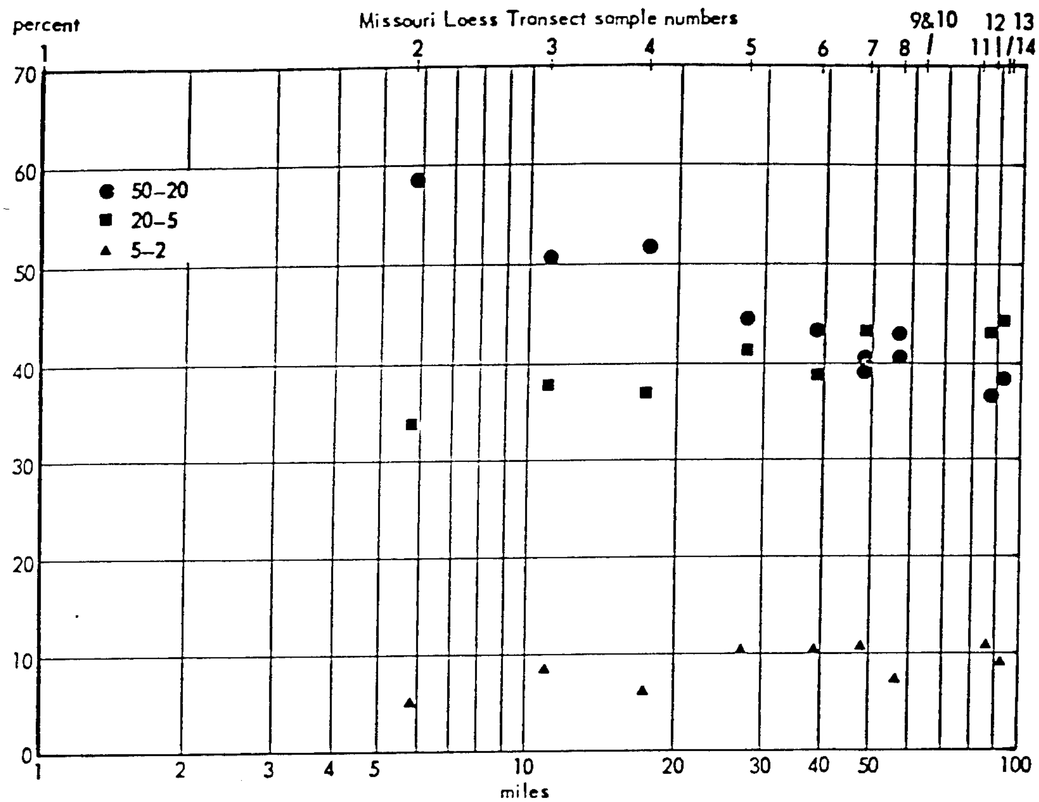

Figure 6. Percent of mean clay-free silt versus log of miles (Waverly-to-Wheatland loess transect).

Table 1

	Distance to Mo.R. Miles (km)	Apparent depth of loess/silt mantle* (cm)	Portion of mantle used for calc. % silt (cm)	# Samples	Mean Clay-free Silts %CSi 50-20μ	%MSi 20-5μ	%FSi 5-2μ	%TSi 50-2μ
MLT 1	1.0 (1.6)	> 590+	0-590	30	63.89 (3.13)	27.98 (3.51)	3.84 (1.42)	95.71 (1.69)
MLT 2	5.8 (9.3)	> 430+	0-430	22	58.27 (3.75)	34.02 (4.51)	5.49 (1.55)	97.79 (0.53)
MLT 3	11.0 (17.7)	> 307+	0-307	16	50.28 (4.06)	37.95 (3.78)	8.86 (2.73)	97.09 (0.96)
MLT 4	17.4 (28.0)	> 590+	0-590	30	51.92 (4.68)	37.03 (4.45)	6.06 (1.38)	95.01 (1.81)
MLT 5	27.4 (44.1)	165	0-130	7	44.56 (2.73)	41.29 (1.46)	10.18 (2.50)	96.02 (1.52)
MLT 6	38.6 (62.1)	105	0-90	5	43.62 (10.01)	38.76 (10.24)	10.34 (3.19)	92.72 (3.79)
MLT 7	48.2 (77.6)	205	0-70	4	40.15 (4.42)	43.43 (5.39)	10.89 (0.69)	94.46 (1.68)
			0-130	7	39.57 (4.20)	43.71 (4.26)	10.22 (1.05)	93.50 (1.88)
MLT 8	56.0 (90.1)	245	0-210	11	43.19 (6.38)	40.60 (4.61)	7.63 (3.80)	91.42 (2.33)
MLT 9 & 10	62.6 (100.7)	?				Mean (Std. Dev.)		
MLT 11	80.4 (129.4)	?						
MLT 12	87.8 (141.3)	185?	0-190	10	36.56 (4.64)	43.29 (4.15)	10.47 (2.41)	90.31 (1.43)
MLT 13 A & B	91.2 (146.8)	?						
MLT 14	90.8 (146.1)	245	0-270	14	38.62 (5.84)	44.74 (4.53)	9.20 (2.93)	92.56 (2.46)

*Inferred from sand percent increase at depth

MLT 1 through MLT 8

The parent material of these profiles appears to be dominantly of loessal origin. MLT 1 was a core taken right on the Missouri River bluffs, overlooking the river, where loess many meters thick could clearly be seen. The parent material of MLT 1 through 4 is apparently entirely loess, and in MLT 5 through 8 there is an increase in sand at depth, which is as expected if the overlying mantle were loess, though depth to the sand varies. A fairly strongly developed soil with good horizon textural differentiation appears in MLT 5 and is present in more distant profiles. Also, the coarse silt decreases with increasing distance from the river (Fig. 6), also as would be expected with loess.

MLT 9 and 10

These two "Warsaw gap" profiles bottomed out on rock and were so shallow that they are of little use for our purpose. Nevertheless, the proportion of silt to clay and sand in the soils is quite high.

MLT 11

This profile was taken from Lost Hill opposite Rodgers Shelter. About all that can be said is that it has a well-developed soil, it has a higher proportion of sand relative to all other profiles, and it has a lot of medium-coarse silt. The silt, or some of it may be of loessal origin.

MLT 12 through 14

MLT 12 and 14 appear to meet the criteria for loess, especially 14. In fact, both profiles appear to have almost too much loess considering their distance from the river (146 km in the case of 14). This can be explained if some of the material is re-worked, and that the initial site was originally lower lying, having been since infilled with slopewash re-worked loess sediments to gain the present thickness. Interestingly, the area is karstic, with many sinkholes and depressions, so that infilling may well have occurred.

MLT 13 is actually two cores that were pulled in the same very flat field just south of Wheatland where Missouri Highway 83 doglegs west, then south. We expected a deeper profile but bottomed out in shallow gravels at about 0.7 m. Even so, most of the profile is dominated by silt, and the surface could be wind (or water?) stripped. The shallow soil present was very well developed.

Is There Loess in the Pomme de Terre Drainage?

The answer to this question appears to be an unequivocal yes. While the data presented here are limited (more transects need to be made) they still provide strong support for the loess map of Figure 1. The biggest problem is the Warsaw gap, where few stable surfaces with intact residual soils exist due to erosion by the Osage River and tributaries. Perhaps given more time and money, an aggressive coring program could solve the problem. Be that as it may, aside from data cited earlier, the most compelling evidence for loess as a dominant silt component of the parent material in the region is the change in silt particle size with distance from the presumed source (Fig. 6). This fits the loess dispersion model well (Fig. 2), the Warsaw gap notwithstanding. (When the silt and clay mineralogy data are available for MLT 1 through 14, where surface mineralogies can be compared with each other and, especially, those at depth [MLT 7 through 14], much more light will be shed on the matter.)

Age and Brown Color of the Rodgers Alluvium

In view of the fact that the Rodgers alluvium is dominated by silt, now inferred to be principally re-worked loess, it seems reasonable to conclude that the silt was Peorian loess of late Pleistocene - early Holocene age. If correct, it fits a consistent Peoria loess pattern through the Midwest, of which the Osage Basin is a part. Further, the Rodgers alluvium ranges in age from 10,500 to about 1,500 RYBP (Haynes 1981), which is age consistent with the interpretation that it is re-worked Peorian loess.

The "raw" loess in the C horizon of MLT 1, essentially at the loess source, ranges in moist color from brown to light yellowish brown (10YR 5/3-6/4) to dark and light brown (7.5YR 4/4-6/4). A typical color range for Rodgers alluvium in the lower Pomme de Terre valley is dark brown to brown (10YR 3/3-4/4), and soils formed in it can be dark grayish brown to strong brown (10YR 4/2-7.5YR 5/6; see this report, and Haynes 1981). It thus appears reasonable to conclude that the color of the Rodgers alluvium principally reflects the original Peorian loess parent material, though post-depositional pedogenesis and oxidation may well have played some role, as Haynes (1981) suggests.

Age and Dark Color of the Pippins Alluvium

Moist colors of the Pippins alluvium range from very dark brown to dark brown (10YR 2/3-7.5YR 3/2), which contrast with the lighter brownish colors of Rodgers alluvium. Why was there a color change? The answer, while speculative, may be tied to the young age of the Pippins alluvium (<1000 RYBP, probably mainly less than 800 RYBP; Haynes 1981). Presumably Peorian loess deposition had effectively terminated by middle Holocene time, though a lag period may have ensued which fed loess into the area river basins through middle to late Holocene time. At any rate, by 1000 or 800 years ago, material entrained by Osage Basin tributaries, such as the Pomme de Terre river, would likely not have been raw loess, except for occasional re-eroded Rodgers alluvium. Stabilized inter-fluve soils, however, if eroded, probably would have contributed principally dark-colored humified A horizon material to the area drainage basins with increasingly minimal dilution by loess with time, reworked or otherwise. Such a pattern of principally (though certainly not entirely) soil A horizon erosion and fluvial entrainment may be the normal situation in late Holocene time in the absence of fresh loess inputs (such as characterized early and middle Holocene time). The contributions of humified A horizon material may have increased, perhaps markedly, during the late Archaic and, especially, Woodland periods when cultivation was accompanied by forest clearing (McMillan 1970). This was also roughly a time when climate and vegetation was shifting from less mesic conditions to the modern regime (McMillan 1976; Purdue 1980). This interpretation is consistent with the much higher aggradational rates of the Pippins alluvium over the Rodgers and earlier alluviums, though the time for its aggradation was much less (Haynes 1981). It is also consistent with the coarser grain size of the Pippins over the earlier alluviums (Haynes 1981; Miller 1982). Haynes (1981) suggested that some of the dark colors may be due to charcoal, indicating an upsurge in late Holocene burning by Indians to

improve game conditions (King 1977). The author and colleagues have noted a greater frequency of charcoal in the Pippins alluvium over the Rodgers alluvium, so that it may well be that a combination of burning and forest clearing coacted to produce accelerated erosion of surface horizons, resulting in the dark color and coarser grained character of the Pippins alluvium, as opposed to the browns of the reworked loess-dominated Rodgers alluvium.

The Regional Synchroneity of Loess Accumulation in the Ozarks and Surrounding Area

Since the present climate of the Ozarks is regional in extent, that is a humid continental hot summer - cold winter climate covers the area, one would expect that at any given point in time the climate pattern of the Holocene across the area would also have been regional. On the assumption that the above inference is valid, it also seems reasonable to suppose that episodes of loess accumulation, interfluve stripping, alluviation, and soil formation were, likewise, regionally synchronous. In fact, soil geomorphic data at a number of sites across Missouri, from Kansas City to St. Louis, strongly suggest that a regional synchroneity of events existed. In addition to the number of sites on the Pomme de Terre, Sac, and Osage Rivers that have been investigated, the writer has studied the soils and alluvial sediments at the Sohn site on the Little Blue River near Kansas City, the Feeler Site on the Gasconade River near Rolla, and the Kimmswick Site at the confluence of Rock and Black Creeks near St. Louis. The Rodgers alluvium, or its near equivalents, and its contained soilscape is present in each area, though, at Kimmswick the T-1b terrace, lies below carbonate bluffs and has a colluvial component. The T-0 terrace, with Pippins-like alluvium, is also present at each of the above-named sites except Kimmswick, where the writer did not observe it (though it may be in the vicinity). Analysis of soil - sediment - topographic - chronologic relationships of one or more of each of these sites is found in Haynes (1981), Graham et al. (1981), and Johnson (1977a, 1981a, 1981b).

Interestingly, the writer also had occasion to study the soils and sediments at the Bug Hill Site, Clayton, Oklahoma, where a near identical T-1b terrace, Rodgers-like alluvium, and Rodgers-like soilscape occur on an early to middle Holocene terrace of Jackfork creek (Johnson 1981c) (Fig. 7). Clayton is 260 km south of Joplin, Missouri, 70 km west of the Arkansas border and lies within the west central portion of the Ouachita Mountains structural province. The writer was surprised and impressed with the similarity, indeed almost identical character of the alluvium and contained soil in the Jackfork Basin to the Rodgers alluvium in the Osage Basin. Moreover, the age of the Jackfork terrace essentially matches that of the T-1b terrace of the Osage Basin. On this basis, the writer provisionally concluded that they are approximate correlatives. If correct, it suggests a very broad regional synchroneity of loess accumulation; interfluve stripping, alluviation, valley fill entrenchment, and soil formation for the Ozarks-Ouachita region. Obviously many more studies will be necessary in the Ozark-Ouachita transition zone to confirm such synchroneity.

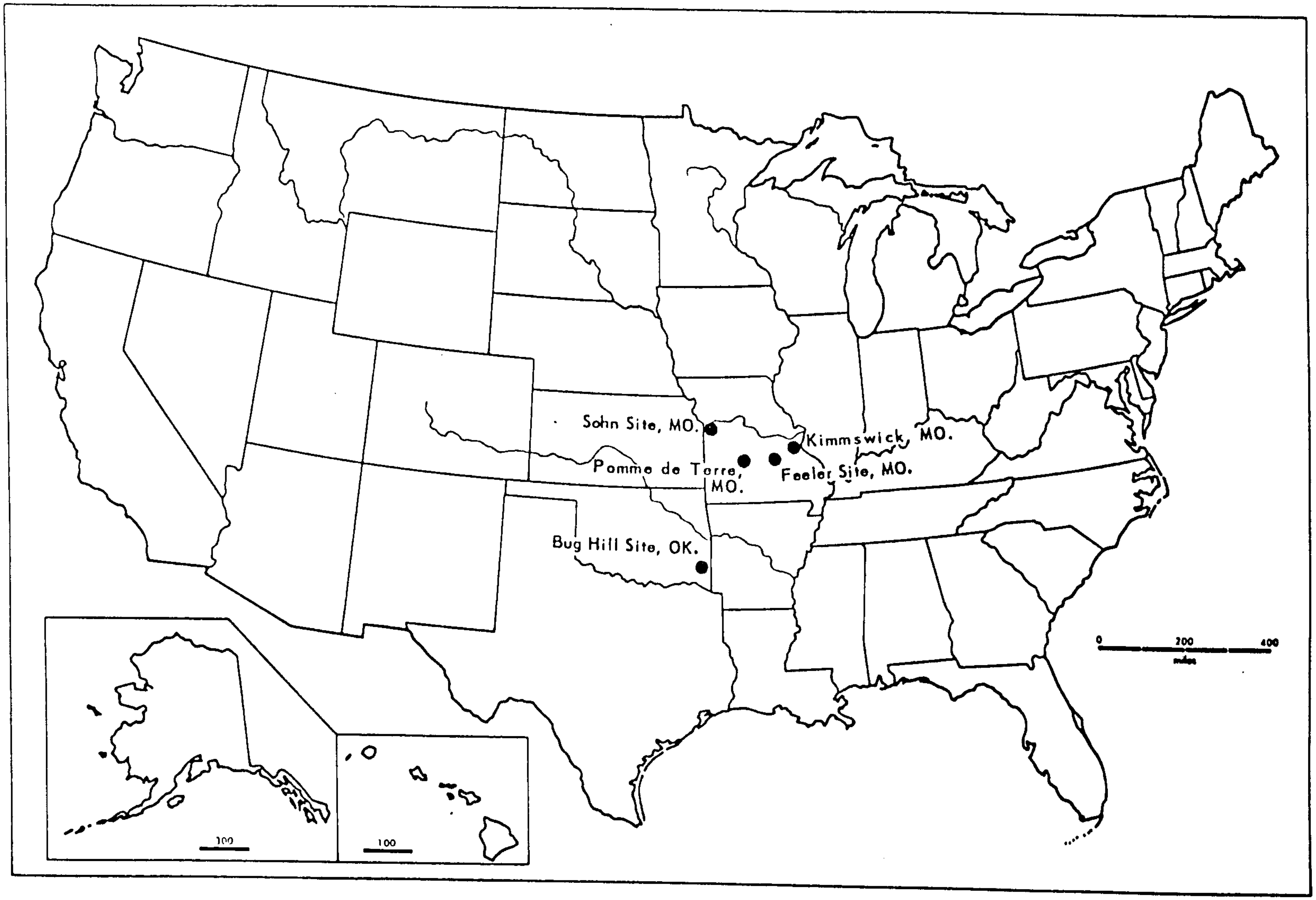

Figure 7. Areal relationship of study areas referred to in text where Rodgers or Rodgers-like alluvium of early-mid Holocene age occurs.

Conclusions

The data of this chapter strongly suggest, if not prove, that a significant eolian input of loess, almost certainly Peorian loess, entered the Osage River Basin during the late Pleistocene and early to middle Holocene. The source was principally from the Missouri River to the north. The loess apparently blanketed the basin, was eroded off the basin interfluves and fluvially entrained and redeposited as alluvium. Earlier alluvial units, or portions of them, also probably owe their origin to loess (Haynes 1981).

The brownish color of the Rodgers alluvium appears principally to owe its origin to the brownish color of the raw Peorian loess. The darker color of the Pippins alluvium appears to owe its origin to humified A horizon material stripped via accelerated erosion from interfluves during the Woodland period, probably initiated by forest clearing and burning by Indians.

The model presented here, of river alluvium of Holocene age in the lower Pomme de Terre valley derived principally from re-worked Peorian loess, is applicable state-wide in Missouri and, perhaps, beyond.

Chapter Three

NATURE OF SOIL DEVELOPMENT IN SELECTED AREAS OF TRUMAN RESERVOIR

Chapter Content

This chapter sheds light on central questions discussed in the Introduction. Specifically, it investigates why certain soil patterns occur in the study area, why buried soils are not more apparent in alluvial units away from valley bluffs, and why do some soils show more developed attributes than other soils. An introduction to the physical geography of the region, with emphasis on the Pomme de Terre basin is followed by assessments of soils at locations near Avery Bridge, Koch Spring, Sac River (Montgomery Site), Wolf Creek, and the Hand Site.

Introduction

The Geologic Setting

The Pomme de Terre basin, the principal study area of this chapter, lies between the Salem Plateau on the east and the Springfield Plateau on the west, traditionally considered to be two subprovinces of the Ozark Plateaus physiographic province (Fenneman 1938). The Springfield Plateau is now included with the plains to the west rather than the Ozarks (Bretz 1965); thus, the Pomme de Terre marks the western edge of the Ozark Plateaus in Missouri.

Structurally the Ozark uplift is a broad asymmetrical dome, with its highest point in the Pre-Cambrian igneous rocks comprising the St. Francois Mountains (Thornbury 1965). The drainage pattern is approximately radial, with streams extending from the mountains across the surrounding Salem Plateau. The Salem Plateau is composed largely of sedimentary carbonate bedrock, forming a landscape of broad, flat uplands dissected by numerous streams. Relief associated with major streams is about 170 m in the southern plateau area and about 100 m along portions of the Osage River (Tarr 1924; Thornbury 1965). The Pomme de Terre in Benton County is about 200 m above sea level and 60-90 m below the surrounding uplands (Saunders 1979). Bedrock in the immediate area is the cherty Jefferson City dolomite of Ordovician age (Allen et al. 1975).

Although the Missouri Ozarks are not a major area of classic karst topography, solution of the carbonate bedrock has been an important process in forming the landscape. The underground drainage system is especially well developed in the limestone and dolomite on the Salem Plateau, which is highly cavernous and contains numerous karst sparings (Beckman and Hinchley 1944; Thornbury 1965). The largest springs occur in rock formations which are primarily dolomite or dolomitic-limestone. Smaller springs and seeps, emerging as artesian springs in the floodplains or on the lower

valley sides, are so common that Sauer stated "almost no Ozark valley is without abundant spring water" (Sauer 1920, p. 51). Artesian springs in the lower Pomme de Terre valley have proven to be major paleontological sites (Saunders 1979). Figure 8 locates the bone bearing springs in relation to other sites discussed in this chapter.

The terraces along the Pomme de Terre have been mapped by Haynes (1976, 1981) and Brakenridge (1979, 1981). The study site which is the principle focus of the chapter occurs on the terrace T-1b immediately above the surface T-0 which was the modern floodplain before the Pomme de Terre Dam was built (Figure 9). Radiocarbon dates from charcoal found within the T-1 alluvium (informally called the Rodgers alluvium) indicate that deposition began about 11,000 RYBP (radiocarbon years before present) and ended about 2,000 RYBP (Haynes 1976, 1981; Ahler 1976; Kay 1980). Two dates were obtained from charcoal found in the Rodgers alluvium in the immediate vicinity of the study site (within 100 m), 3,985 RYBP from a depth of 4 m and 4,585 RYBP from a depth of 4.5 m (Haynes, personal communication 1979).

Climate and Vegetation

The western Ozarks are on the climatic and vegetation ecotone separating the deciduous forest on the east from the prairies on the west and north (Borchert 1950; Sauer 1920; McMillan 1976). Prairie grasses on the relatively flat uplands occur in patches among stands of oak-hickory or pine-oak forest, a pattern characteristic of all of the Prairie Peninsula margin (Steyermark 1963). Prior to settlement of the area by Caucasians, the natural vegetation of the lower Pomme de Terre valley was probably bottomland forest on the floodplain (oak-hickory with some sycamores, walnuts, maples, and bottomland shrubs) and oak-hickory forest on the terraces (McMillan 1976). Where locally distinctive micro-habitats are created by spring seeps, specialized swamp and aquatic vegetation usually occurs (Steyermark 1963).

The present climate of the ecotone is variable, humid but with low winter precipitation and occasional summer droughts similar to those which characterize the prairies and plains to the west (Borchert 1950). Mean annual precipitation is 109.5 cm with peaks occurring in the spring and fall; mean January temperature is .72 C, and mean July temperature is 26.3 C (Table 2). The growing season is about 188 days, with the last killing winter frost occurring in April or May and the first killing fall frost in September or October (Steyermark 1963; Saunders 1979). During extended droughts, the prairie expands, later retreating when precipitation increases and forest vegetation is again favored (McMillan 1976; King and Allen 1977).

Although the Ozark Plateaus are south of the maximum southern extent of glaciation, the climate and vegetation changed as a result of Pleistocene climatic fluctuation. Pollen recovered from artesian springs in the Pomme de Terre valley indicates that spruce was common during full glacial periods, with a pine parkland present during the mid-Wisconsin interstade, and a mixed spruce-deciduous forest following the late Wisconsin glacial maximum (King and Lindsay 1976; King 1973). The present oak-hickory forest is a post-glacial phenomenon.

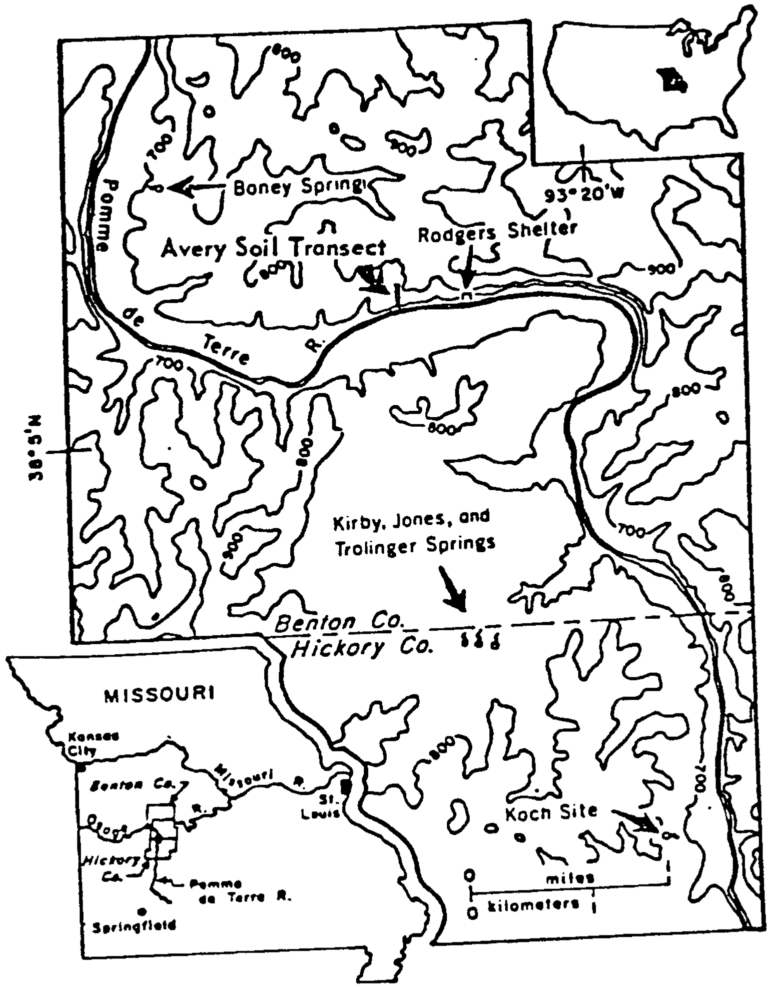

Figure 8. Map of the lower Pomme de Terre study area. In Benton County, Missouri, the lower Pomme de Terre River meanders in a northwesterly direction. The soil/moisture transect is located on a terrace on the north side of the river (modified from Wood and McMillan 1976).

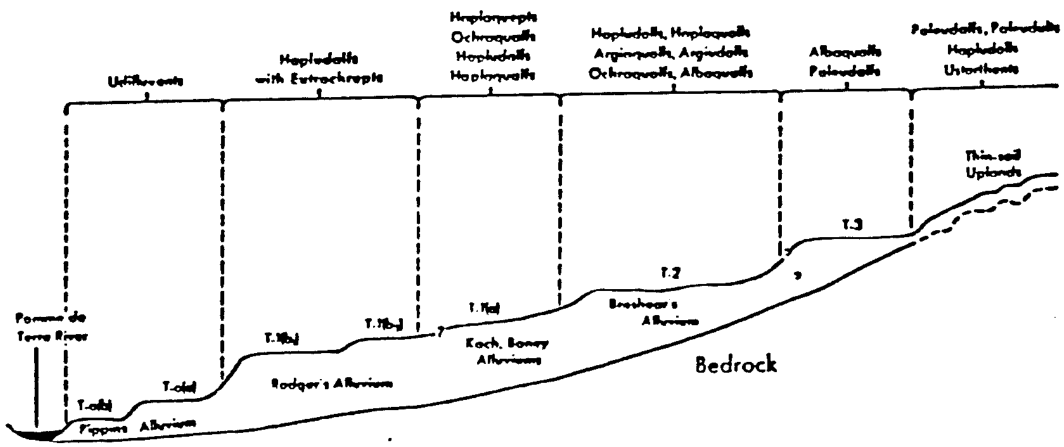

Figure 9. Diagram of alluvial terraces bordering the Pomme de Terre. Alluvial terraces were mapped by Haynes (1976, 1981) and Brakenridge (1979, 1981). Soils were mapped by Johnson (1977a) and Johnson and Miller (1977a). The Avery Bridge site is located on the Rodgers alluvium, a Holocene-aged terrace.

Table 2 Precipitation and temperature at Warsaw, Missouri: Mean values for a sixty-seven year period.

	Month					
	Jan.	Feb.	Mar.	Apr.	May	June
Mean Precipitation	5.28	5.44	7.92	10.72	12.98	14.00
Mean Temperature	0.72	2.38	7.88	13.88	18.83	23.72

	Month						
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean Precipitation	9.75	10.77	11.73	9.04	6.38	5.49	109.5
Mean Temperature	26.33	25.83	20.61	15.33	8.11	2.38	13.93

Precipitation is given in centimeters; temperature is given in Centigrade. From Wernstadt 1972, page 466.

The Avery Bridge Study Site

As mentioned earlier in this report, soil-mapping conducted during 1975-1977 (Johnson and Miller 1977) revealed several very interesting soil patterns. For example, the Rodgers alluvium has soils developed in it that range from those that show minimal development (Inceptisols) to those that show maximal development (Alfisols). Since the parent materials are approximately the same age, the differences in pedon development must be due to a non-time factor (cf., equations 3 and 4 in Introduction). Additionally, strongly developed (horizonated) soils (e.g., Albaqualfs, Haplaqualfs) invariably occur in the vicinity of springs, or at the base of slopes where water collects. It was hypothesized that these were "high energy" soils in the Rungian sense. That is, in equation (4) water is the organizing (energy) vector and, other things equal (an admittedly rare condition) the more water that is available the more energy is available for organizing soils through leaching, translocations and transformation (the r, t_1 and t_2 factors of equation (1)).

To test this hypothesis, a small area near a karst spring in which all major soil forming factors except moisture are the same, was chosen for investigation. The spring is located on terrace T-1b just west of an old, now destroyed, suspension bridge called Avery Bridge (Figure 8). The site, informally called the Avery Bridge site, is nearly flat, about 5 m above the Pomme de Terre River, and has been cultivated for many years. A spring emerges from dolomite bedrock near the base of the adjacent valley side wall and water from it seeps across and through the terrace sediments toward the river (Figure 10). The spring water has been partially captured in a stock pond on the north edge of the field, but during periods of moderate precipitation seepage is visible at the soil surface over an area about 10 m out into the field. No standing water is present during dry periods, but the visibly affected area has been observed to double in size if precipitation is intense or prolonged.

Field observations of the soil within the seep and immediately outside it were made in the summer of 1977 when a backhoe trench was dug along a transect across the field. The differences in moisture content and movement were obvious at this time, as saturated soil within the seep (standing water on the trench floor, water flowing freely down the trench walls) contrasted with moist but unsaturated soil further out in the field (no free water). The soil within the seep had the appearance of a high-energy profile relative to adjacent soil farther down the transect. A greater volume of percolating water, or a greater frequency of wet/dry cycles, has been associated with increases in the amount of clay moved within a profile (Hallsworth 1963; Runge 1973). Differences in soil morphology along the trench wall transect were quite subtle, however.

Purpose

The purpose of this phase of the study was to compare relative strength of development of the soil affected by the seep with that farther out in the field. In short our purpose was to test Runges energy model (equation 4). The degree of clay translocation, or the relative strengths of textural B (argillic)

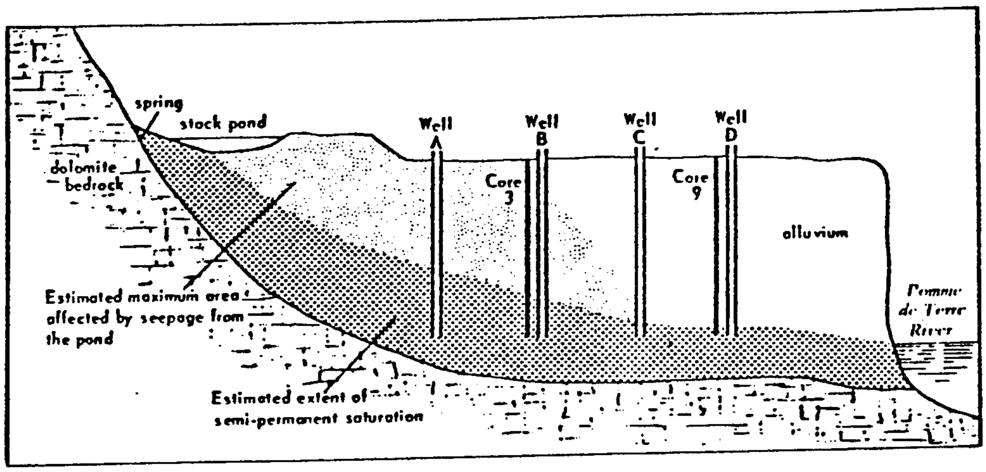

Figure 10. The spring seep at the Avery Bridge site. Location of the transect with respect to the dolomite bluff and spring is shown (not to scale).

horizons by downward percolating water is a good indicator of relative energy inputs (eg., high energy = strong argillic horizons; low energy = weak ones).

Argillic horizons are useful in paleoenvironmental reconstruction research because they are both common and durable. They may occur as paleosols, often buried beneath younger material, in which case they may indicate the presence of a formerly stable surface (Yaalon 1971). Layers of this type were found at Rodgers Shelter, a short distance upstream from the Avery Bridge field (Ahler 1973a; 1973b; 1976). Understanding the processes which create argillic horizons is important where such paleosols are used to help describe the past environment of the area.

Hypotheses of Clay Migration

Two hypotheses about the nature of clay migration at the Avery Bridge site were generated for this research (the theoretical basis of each is explained in following sections).

1. Clay migration within the seep-affected "wet" soil will be greater than migration within the adjacent "dry" soil because a greater volume of water flows through the "wet" soil. If this is the case, the argillic horizon will be more strongly developed at the wet end of the moisture gradient closest to the seep.

2. Clay migration within the seep-affected "wet" soil will be less than migration in adjacent "dry" soil because the influx of dissolved divalent cations in the spring water will tend to flocculate the clay, preventing effective translocation to the B horizon. If this is the case, the argillic horizon will be more strongly developed at the dry end of the moisture gradient, farthest from the seep.

Although the first hypothesis, which is derived from Runge's model of soil formation, is favored, the second is also suggested because antagonistic conditions appear to exist together at this site, and presumably in similar areas throughout the midlatitudes. Clays are believed to be relatively immobile under some chemical conditions, one of which is a high divalent cation content (especially calcium) in the soil. However, a large amount of downward water movement is believed to increase clay movement, all other factors being equal. If the source of the percolating water is also a source of divalent cations, it is questionable whether or not clay movement will occur under natural conditions. Investigation of the soil at the Avery Bridge site should provide answers to this question, and increase our understanding of argillic horizon development under high calcium/magnesium conditions.

Formation of Argillic Horizons

An argillic horizon is a subsurface horizon in which clay has accumulated as the result of pedogenic processes (i.e. eluviation/illuviation) (Soil Survey Staff 1975). The vertical distribution of clay in a poorly developed alluvial

soil reflects depositional rather than pedogenic processes (Barshad 1964).[3]

In a mature soil the amount of clay increases with depth to a maximum, then decreases until a constant level is reached or the depositional pattern is resumed. Some portion of the clay in the B horizon is presumed to have been moved, suspended in percolating water, from the A horizon to the B horizon (eluviated), where it is deposited (illuviated) along pores, channelways, and ped surfaces. Illuvial clay occurs in films called argillans in these locations. Clay in argillans lies with the particles oriented parallel to one another, creating an optical effect which can be seen in soil thin sections under a polarizing microxcope (Brewer 1964). Direction of water movement is apparently unimportant since optically oriented argillans have been produced in the laboratory by capillary rise of dilute clay suspensions into sand columns (Brewer and Haldane 1957). If the amount of clay in the B exceeds that in the A by at least twenty percent, and if at least one percent of that clay is in the form of argillans containing optically oriented clay, then the horizon is an argillic horizon (Buol and Hole 1961; Soil Survey Staff 1975). The formation of distinct argillic horizons in the mid-latitudes is believed to require one or more thousands of years, depending on the climate in which the soil is forming (Bilzi and Ciolkowsz 1977; Parsons and Herriman 1976; Soil Survey Staff 1975). The basic conditions that must be satisfied before an argillic horizon can form is detailed in Watson Stegner (1980).

To summarize, two types of soil may exist at the site. They differ only in the volume of moving water which passes through the profile and in the amount of enrichment of divalent cations that occurs. Both water and cations are supplied in greater amounts to the spring-affected "wet" soil than to the adjacent "dry" soil. General conditions at the site should favor migration of clay, but whether or not migration is enhanced by the seepage of spring water is difficult to predict from the theories discussed above.

Methods of Study

At the Avery Bridge site sampling was done along a transect across the field, perpendicular to the river (Figure 11). The transect paralleled the 1977 trench, which had been backfilled the same summer. The spring seep was estimated to cover an area about 5 m wide and 10 m long in the field south of the stock pond, which was separated from the field by a fence. The transect extended about 30 m from the fence toward the river. All sampling was done beside the former trench in undisturbed soil during a summer when the field was not under cultivation.

Prior observation of the trench walls and shown that a considerable amount of free water was present at the end of the transect nearest the pond. At the time the trench was open the soil within the seep was saturated, while soil at the other drier end of the transect wasn't. The presence and properties of the moisture gradient along the transect were established by measuring saturated water flow in the soil, specifically the depth to the free water surface. The variation in this depth over space (along the transect) shows the shape of the water table; the variation over time shows to what extent the upper soil profile is affected by ground water. Accordingly, four positions

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[3]In the mid-latitudes a "mature" or well-developed soil is one which has morphological characteristics showing clear variation with depth (that is, good horizonation). An immature or poorly-developed soil has poorly defined horizons (Crocker 1952).

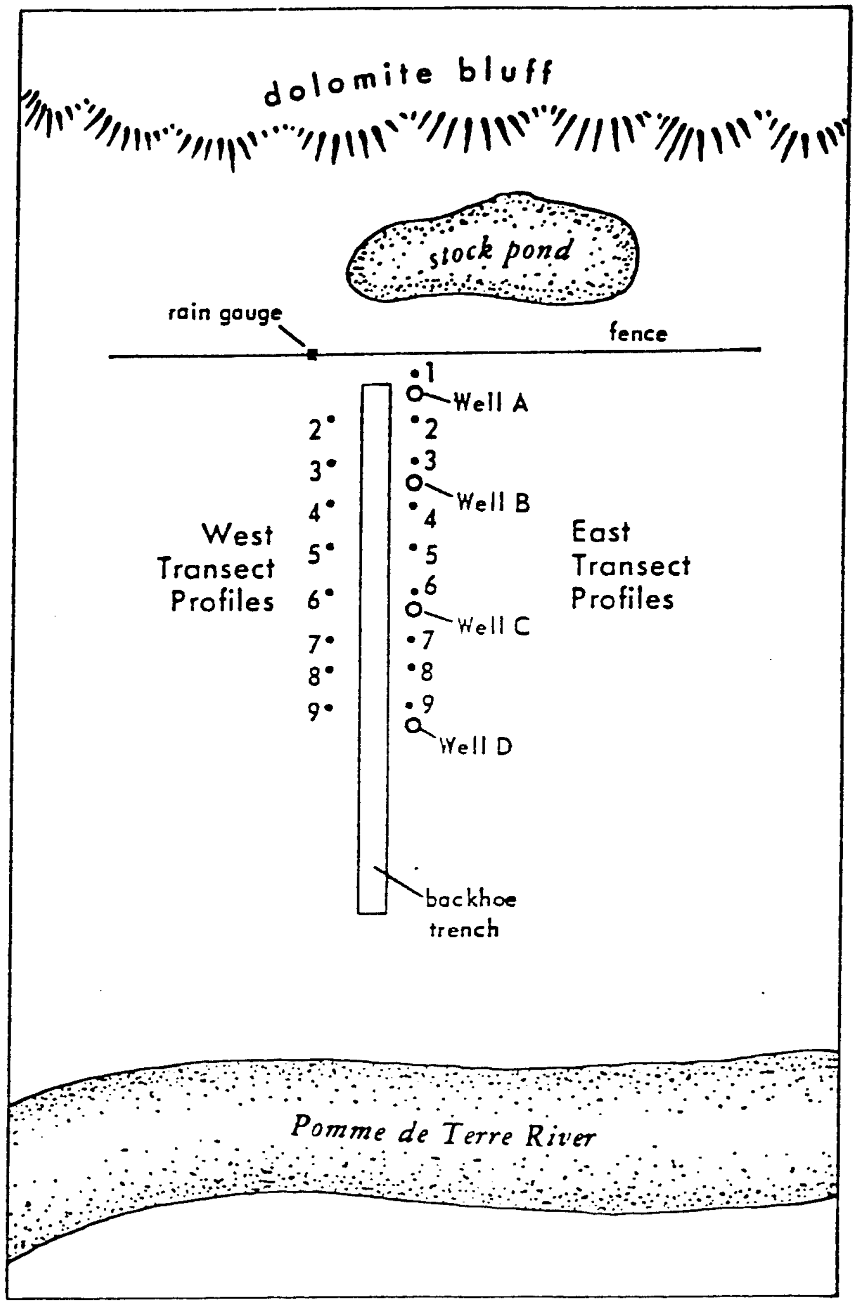

Figure 11. Soil profile and well locations at the Avery Bridge site. The moisture gradient extends across the field from the fence on the north side toward the river on the south.

along the transect were selected for installation of wells for measurement of depth to the water table (see Figures 10) and 11).

Four soil cores, 7 cm in diameter and 4.8 m long, were removed from the well locations along the transect. Drilling was done with a Giddings hydraulic-powered drilling device mounted on a truck. The holes were lined with rigid plastic pipe perforated at 10 cm intervals along the entire length. Gravel was packed around each pipe to fill any space between the soil and the pipe. Each pipe extended a few centimeters above the ground surface and was protected from run-on by a short outer pipe of larger diameter. This outer pipe was covered with a lid to exclude precipitation. The wells were labeled A through D, with A located about 1 m south of the fence, B 6 m south of A, C 9 m south of B, and D 9 m south of C.

The depth to the water table was measured at each of the wells daily over a four month period, from August 4 to November 30, 1978. Long wooden measuring rods marked at 1 cm intervals were placed in the wells. Powdered cork was dropped into each well. Measurements were made by removing the well lid, pulling up the wooden rod, and recording the depth at which bits of cork were found clinging to the rod. A capillary fringe of water usually extended a few centimeters above the cork level. Cork was then brushed off the rod, which was reinserted in the well. A level line was set up along the transect over the wells and data are reported as depth from the level line to the water table, unless otherwise indicated. The level line was 79 cm above A, 86 cm above B, 78 cm above C, and 96 cm above D. The purpose of the level line was to provide a horizontal datum from which to measure the true shape of the water table, not confounded by minor topographic variation.

Precipitation was also measured daily over the four month period. A small plastic rain gauge was nailed to a fencepost near well A. The discharge rate, in cubic feet per second, from the nearby Pomme de Terre Dam at Hermitage, about 30 km upstream, was obtained from the Army Corps of Engineers in order to ascertain whether large variations in the discharge rate might alter the river level sufficiently to affect the gorund water at the site, an effect which would probably be most apparent closest to the river (well D).

Undisturbed soil cores were collected with the Giddings drilling rig at 3 m intervals from two parallel transects, about 2 m on either side of the former trench (Figure 11). The east transect coincided with the well transect and eight from the west transect. Profiles 1, 3, 6, and 9 (east transect) coincided with the locations of wells A, B, C, and D respectively. The cores were 3-4 m long (except 1 where the soil was too wet for deep drilling) and either 7 cm or 4 cm in diameter. After removal from the ground the cores were wrapped in plastic and taken to the laboratory for formal description and analysis.

Descriptions, chemical analyses, and particle size analyses were done for profile 1 (east transect) and 2 through 9 (west transect). Thin sections were made from profiles 3 and 9 (east transect). Clay mineral analysis of profiles 3 and 9 (west transect) was done by x-ray diffraction. These two locations were selected because they represent the "wet" end and the "dry" end of the transect respectively.[4] Details of these methods are given in Watson Stegner (1980).

[4]The east transect profiles 2 through 9 were originally collected for determination of water content by the gravimetric method. This analysis was discarded in favor of water table measurements because water present in the soil under saturated conditions was lost when the samples were removed from the ground. Water content is thus a poor measure of the actual soil moisture conditions.

Results

1. Water table and ground water analyses

The distances (cm) from the level line to the free water surface as measured daily from August 4 through November 30, 1978, are given in Table 1 AC, Appendix C. The table includes daily precipitation records (cm) and the rate of discharge from the Pomme de Terre Dam (cubic feet per second) over the same period. Soil profile descriptions, particle size, thin section analyses and diffractograms are also presented in Appendix C.

The water table at the Avery Bridge site slopes downward from a high level at the north end of the transect to a low level at the south end. This sloping shape was evident throughout the measurement period, and is clearly reflected by the position of the water table at each well (Figures 12 &13). The ground water is consistently higher at wells A and B than it is at wells C and D, a situation which creates a "wet" and "dry" end of the transect. The mean water level at A is 212.9 cm above D in August, 115.8 cm higher in September, 68.5 cm higher in October, and 93.0 cm higher in November (Table 3). Over the same four months, the mean water level at B is higher than D by 184.1 cm, 159.5 cm, 105.6 cm, and 113.1 cm. The position of the ground water at B is higher than at A for most of the measurement period. This may be the result of a slight artesian pressure which occurs naturally or was created by installation of the wells. Field observation showed that there was an aquifer at a depth of about 2.5 meters associated with a slight increase in sand in the north half of the transect.

The variation over time in the water level at each well shows a general slow lowering of the water table over most of the measurement period (Figure 14). Very little precipitation fell during September and October, so recharge of the ground water was minimal. Only well D shows a relatively stable and even gently rising surface. Discharge from the dam ranged from 900 cfs to 100 cfs druing the first three weeks in August, but was a uniform 50 cfs after August 22. The large fluctuations in discharge rate do not coincide with obvious changes in the ground water at wells C and D, where the effect of changing river levels should be most noticeable. The initial instability of the water level in August at wells A and B is probably the result of precipitation before August 4 and adjustment of the water table after installation of the wells.

The general sloping shape of the water table is maintained during storms, but the depth to the free water surface and the degree of slope both change. The water level in wells A and B rises during moderate rain storms. On September 14, 3.6 cm of precipitation, which fell during the previous 36 hours, was recorded at the site. The water level at A rose 15 cm, from 330 cm below the surface on September 13 to 315 cm on September 14. At B the level rose 34 cm, to a high of 265 cm. No change occurred at C and only 1 cm difference was found at D. A similar storm with similar results took place on November 15. Further details of water table measurements are given in Watson Stegner (1980).

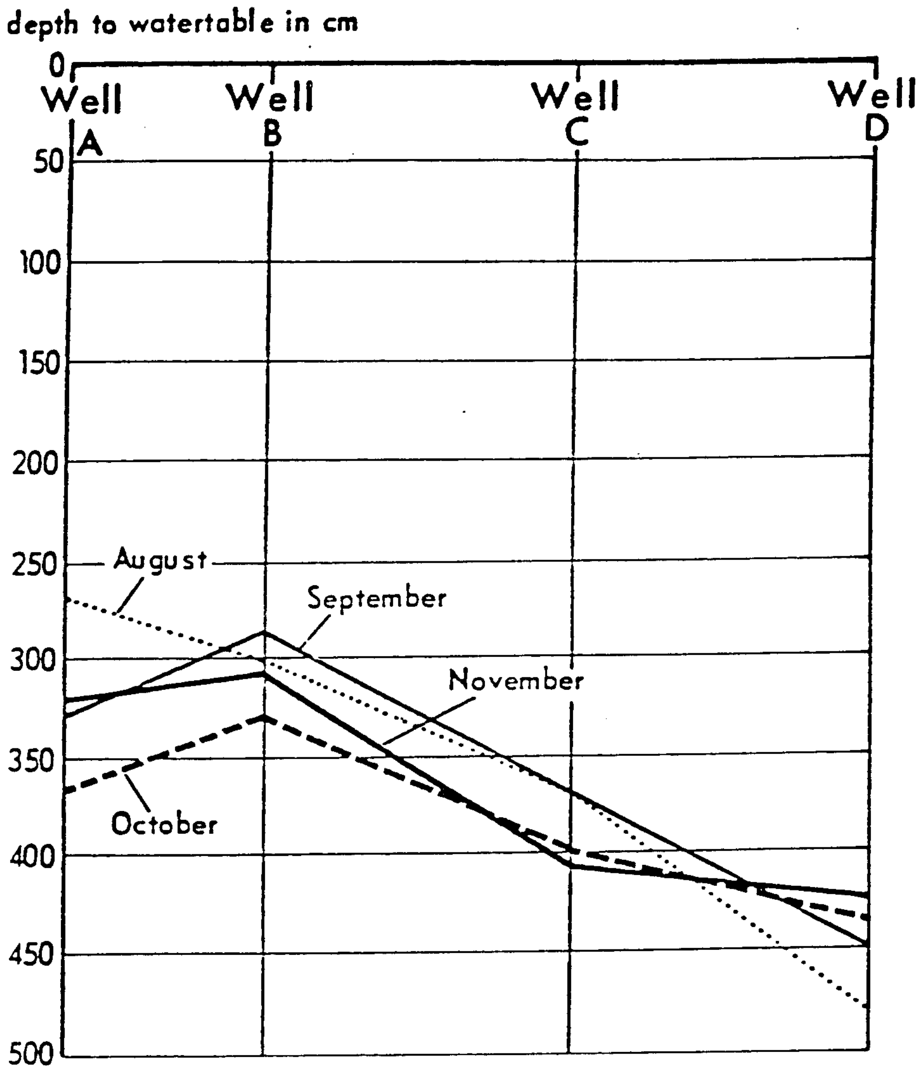

Figure 12. Mean depth to the water table at each well for the four month measurement period. During the summer and fall of 1978 the water table sloped from a high at wells A and B, the north end of the transect, to a low at C and D, the south end. Values given are distances from the level line to the water table.

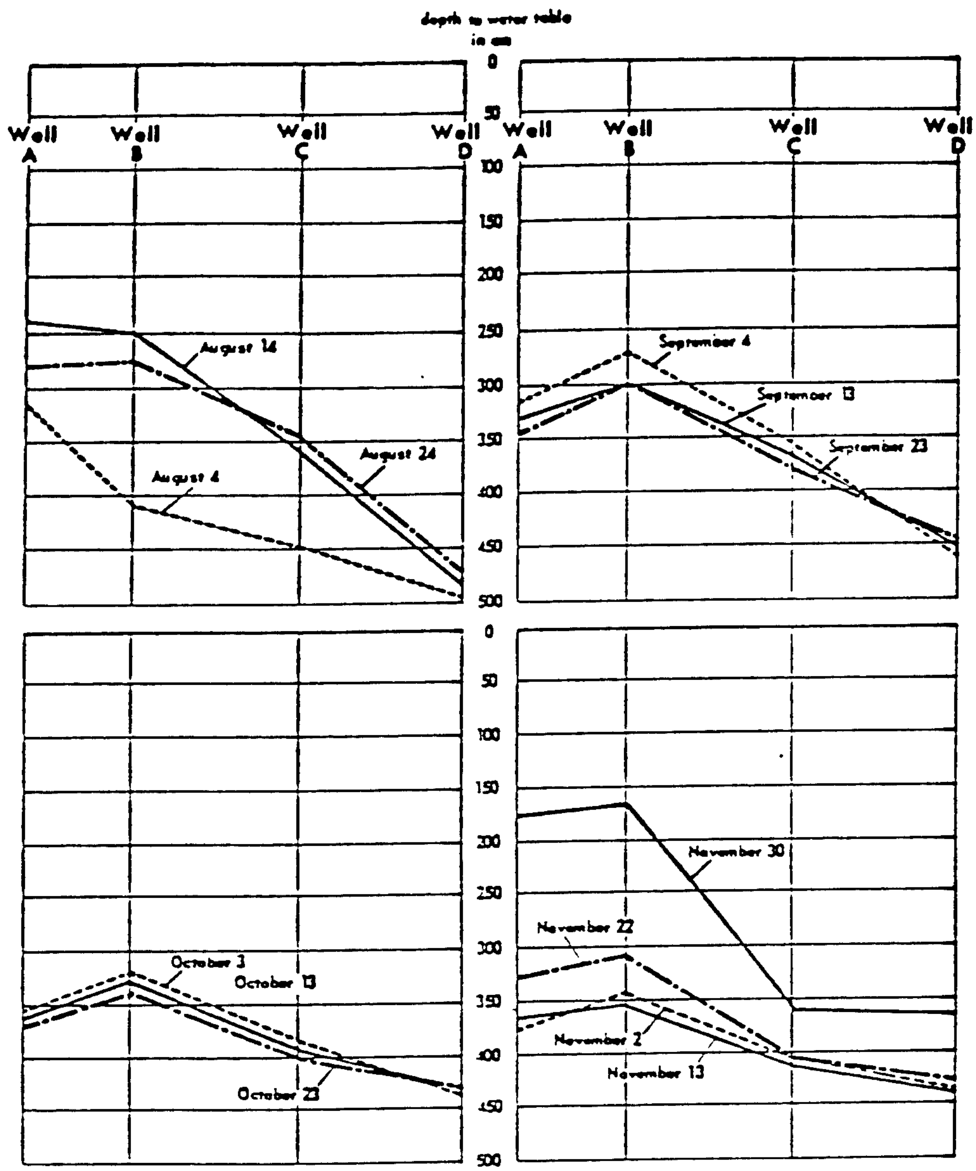

Figure 13. Shape of the water table on selected days throughout the measurement period. The water table on selected days shows the same sloping shape seen when mean values are plotted. The level to which ground water rises is higher for wells A and B than for C and D, especially obvious on November 30.

Table 3. Mean monthly ground water levels at each well

	Month			
Well	August	September	October	November
A	269.2	331.4	367.0	325.6
B	298.0	287.7	329.9	305.5
C	365.4	366.9	394.3	404.8
D	482.1	447.2	435.5	418.6

Mean monthly depth (cm) to the free water surface (from the level line) for August through November, 1978.

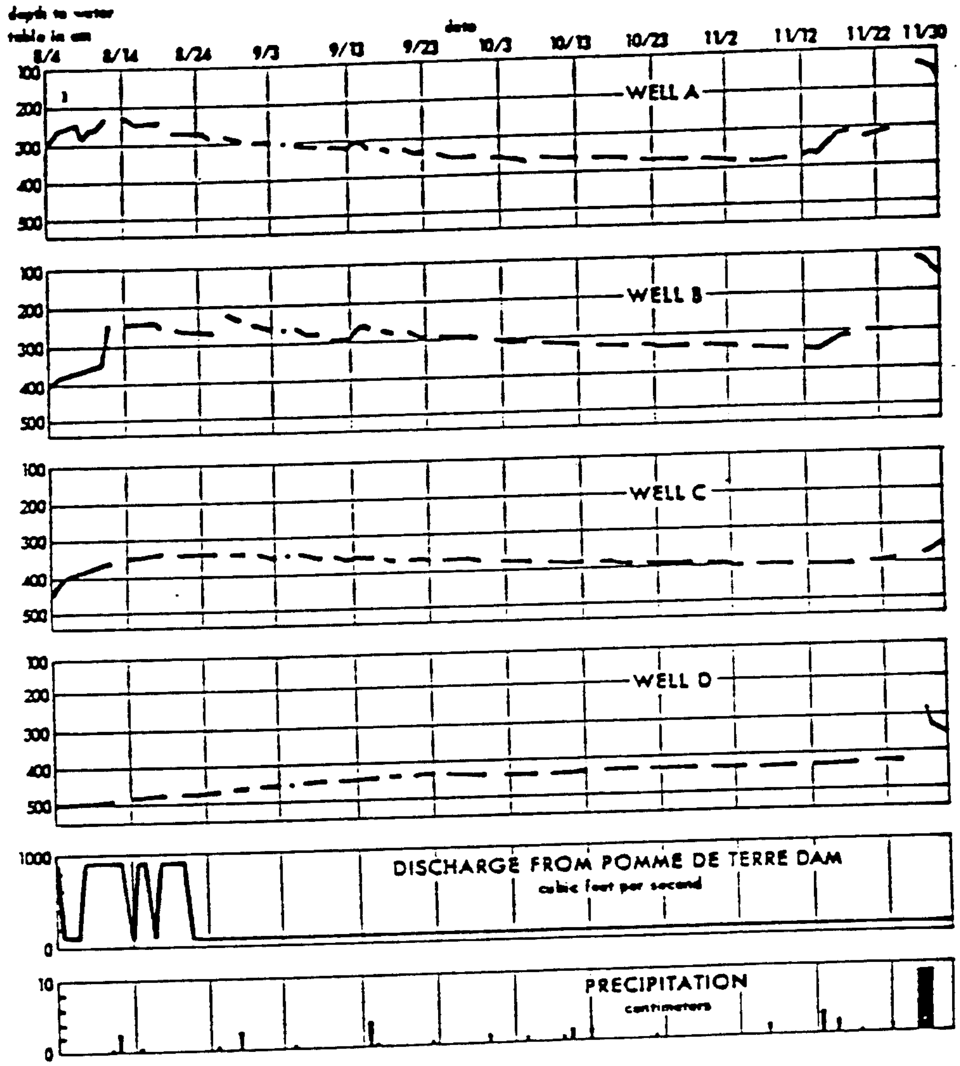

Figure 14. Daily variation in the gound water level. Depth to the water table (from the level line) is shown for each well, from August 4 through November 30, 1978. Blanks indicate days on which measurements could not be taken. Discharge from the Pomme de Terre Dam and precipitation at the site are shown for the same time period.

2. Chemical leaching and enrichment along the moisture gradient

It has been assumed, and the presence of a sloping water table along the transect strengthens the assumption, that the high water level at the "wet" north end is largely the result of seepage from within the calcareous bedrock, although run-on from the adjacent valley sidewall is probably another source. If seepage from the karst spring is the principal source of the extra ground water, then the soil through which the water flows will collect dissolved magnesium and calcium ions. If this is not true, and the soil is not enriched by divalent cations then the profiles at the north end, which have the most percolating water, will appear more leached than the profiles at the south end. That is, profiles 1-3 will have lower pH and base saturation values than profiles farther south along the transect, with highest values in profiles 6 through 9. This will also be true if cations added by ground water to profiles 1 through 3 are being removed as fast as they are being added, by intense leaching. Net enrichment will be indicated by high pH, high base saturation, and high content of divalent cations in soil through which ground water flows.

The nine soil profiles can be grouped into three general categories on the basis of chemical properties, principally pH and percent base saturation. Profile 1 is the only profile in the first group, the second contains profiles 2 through 5, and the third 6 through 9. Because chemical details of these three groups are covered in Watson Stegner (1980) only the summarized results are necessary here. They are:

1. There is a moisture gradient along the transect caused by water seepage through the sediment from the dolomite bedrock. The ground water, which carries with it dissolved magnesium and calcium from the dolomite, rises to the modern soil most frequently closest to the source of the seepage, the dolomite bluff to the north of the Avery Bridge field. The water table slopes downward from a high level at the north "wet" end of the gradient to a low level at the "dry" south end, rarely, if ever, rising to the modern soil at the extreme south end. Therefore, the amount of water available for leaching and eluviation is greatest at the north end and decreases toward the south end.

2. Addition of divalent cations to the soil occurs in the area affected by high ground water, or in the north half of the transect, over an area extended approximately to profile 5, between wells B and C. This enrichment offsets leaching by precipitation and ground water by replacing cations as they are removed. At the extreme north end of the gradient, leaching proceeds at a faster rate than replacement (profile 1). The two processes are more or less in equilibrium in the middle section of the gradient (profiles 2 through 5). At the south end (profiles 6 through 9) leaching again proceeds faster than replacement, but in this area replacement is much slower than it is at the other leached area, the extreme north end of the gradient.

3. Uniformity of the major soil-forming factors

Thus far it has been shown that variations in the amount of percolating water and in the degree of cation replacement/leaching exist along the transect at the Avery Bridge site. However, it was necessary to determine whether other factors of soil formation were constant along the transect. This was done (Watson Stegner 1980) and the factors of slope, parent material, organic matter (vegetation) and time were found to be essentially uniform.

4. General soil morphology

Soil along the moisture gradient at the Avery Bridge site is basically a non-calcareous reddish brown silt loam to silty clay loam with weak subangular blocky structure, best classified as a Hapludalf. The area is free of gravel, although chert fragments are occasionally found. Morphology characteristic of seasonal waterlogging (strong mottling and gleying) is not present, but faint mottling and gleying occurred in several profiles at depths within and below the modern soil (i.e. below 2 m). Iron-manganese concretions are common at some depths in all profiles. These features occur where soil is saturated for a few hours or days at a time, but not below water tables or where saturation is prolonged (Veneman et al. 1976). Concretions are approximately sand-sized particles which can be seen and felt, but the best estimates of their size and abundance were made by examinations of the thin section slides of profiles 3 and 9. Concretions are small and abundant in the upper two meters of profile 3 (presumably above the water table), and are rare below that depth. They are present but less common throughout profile 9. This distribution is in accordance with the measured and inferred characteristics of the fluctuating water table. The moisture regime at the site, even within the seep, is udic rather than aquic, although it is grading toward aquic in the seep-affected soil.[5] The soil at the "wet" north end of the transect is an Aquic Hapludalf, while that at the "dry" south end is a Typic Hapludalf. Further aspects of soil profile attributes is given in Watson Stegner (1980).

5. The argillic horizon

A subsurface accumulation of clay was found in all profiles (Table 4 Figure 15). The ratio of clay in the B horizon to clay in the A is greater than 1.2 in all profiles. In addition, argillans were visible with a hand lens at depths coinciding with the high clay contents, indicating that some of the clay is illuvial.

Photomicrographs of thin sections taken from profiles 3 through 9 clearly show the presence of optically oriented clay along voids and ped faces. The percent of oriented clay by weight in the modern soil is highest (7.2%) in profile 3 where the maximum clay accumulation occurs (Figure 16 and Table 5). The point of maximum oriented clay in the modern soil in profile 9 (4.1%) is at the bottom of the B2t horizon, and is considerably less than the value for profile 3. Since only 1% of the total clay in a B horizon must be in argillans for the horizon to be called argillic, both 3 and 9 qualify on this basis (Soil Survey Staff 1975).

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[5]For a soil to be called "aquic" at the highest level of categorization the entire soil must be saturated most of the time, usually by ground water. Soil conditions are reducing since the water and soil, by definition, are devoid of dissolved oxygen. At lower levels of categorization, the soil need only be saturated at lower depths to be called aquic. A udic moisture regime is humid, with the soil never dry for longer than 90 days at a time. This is the common situation in the humid mid-latitudes, e.g. the eastern deciduous forest area of the United States (Soil Survey Staff 1975).

Table 4. Percent of clay in the nine profiles

Depth(cm)	Profile 1	2	3	4	5	6	7	8	9
0-10	18.2	15.1	17.4	18.1	17.7	16.5	17.5	17.2	17.6
10-20	17.8	15.2	17.1	18.5	17.3	16.5	18.2	17.4	18.2
20-30	17.4	14.0	19.2	19.1	18.1	18.2	21.1	18.6	29.7
30-40	17.1	15.8	19.0	21.7	19.4	19.2	23.9	20.0	20.8
40-50	17.6	15.9	19.8	22.7	21.4	20.5	26.2	19.7	24.8
50-60	17.9	16.1	21.8	24.3	23.9	22.7	27.1	21.0	25.5
60-70	17.1	16.6	23.7	24.7	24.7	25.8	27.6	24.4	26.3
70-80	23.0	17.6	25.8	26.1	26.4	26.9	27.8	27.3	26.7
80-90	27.7	18.6	26.3	25.4	26.0	27.4	26.3	26.5	26.8
90-100	28.7	23.6	28.5	25.5	24.8	26.6	26.3	25.0	24.7
100-110	28.7	25.6	31.6	26.1	25.6	26.4	23.2	24.5	24.4
110-120	29.7	28.3	28.1	26.2	26.2	24.9	24.5	24.4	25.3
120-130	30.9	27.8	26.1	27.5	26.2	25.3	24.6	26.1	26.5
130-140	33.4	28.1	26.8	27.8	28.1	26.3	24.7	27.2	28.3
140-150	32.9	26.8	28.1	28.1	27.8	27.3	26.1	27.7	28.7

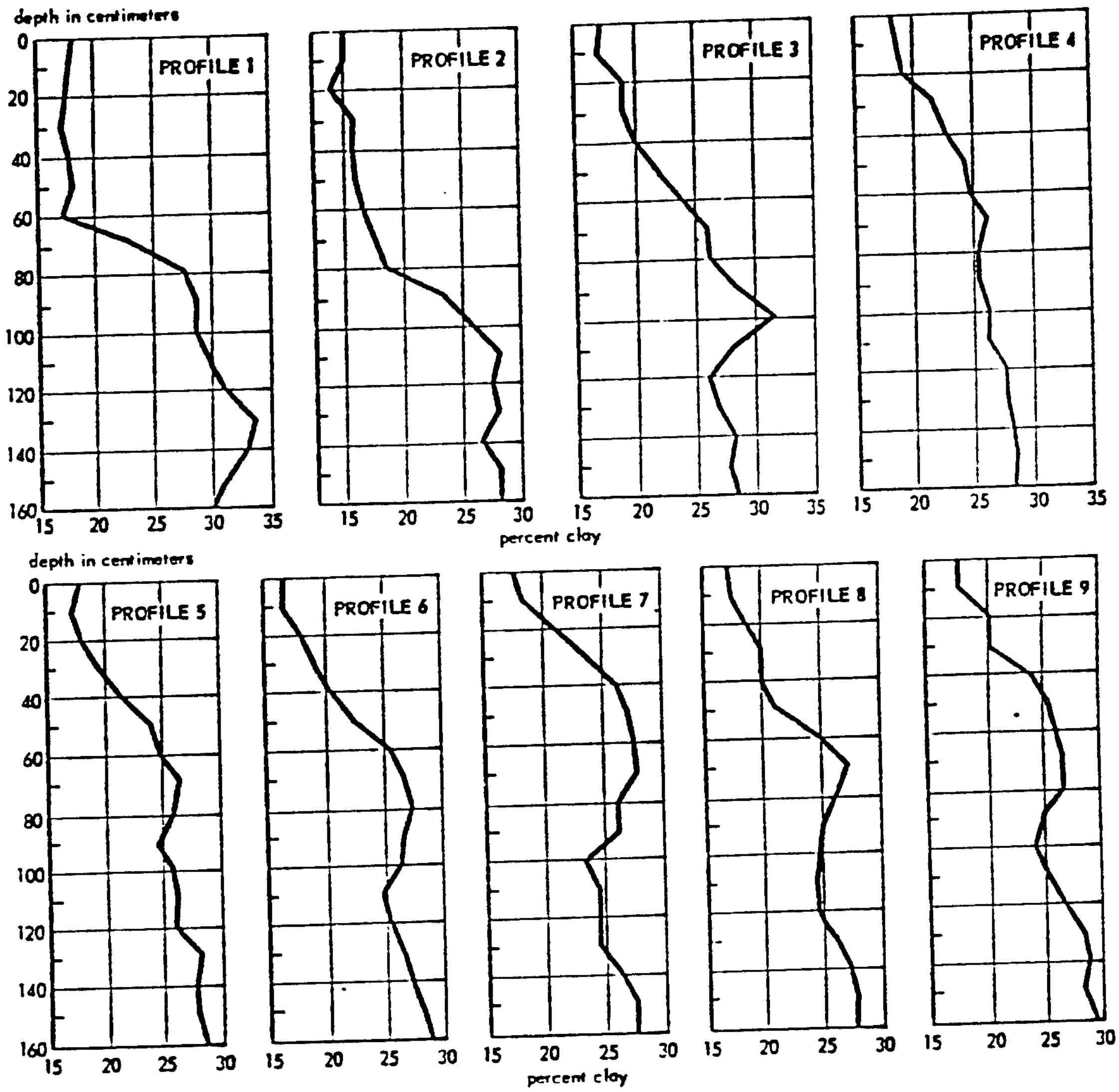

Figure 15. Vertical distribution of clay in soil profiles along the moisture gradient. The variation in clay-sized particles with depth is shown for all nine profiles along the moisture gradient. The B2t horizon is defined primarily on the basis of clay content, presence of argillans containing optically oriented clay, and boundary characteristics.

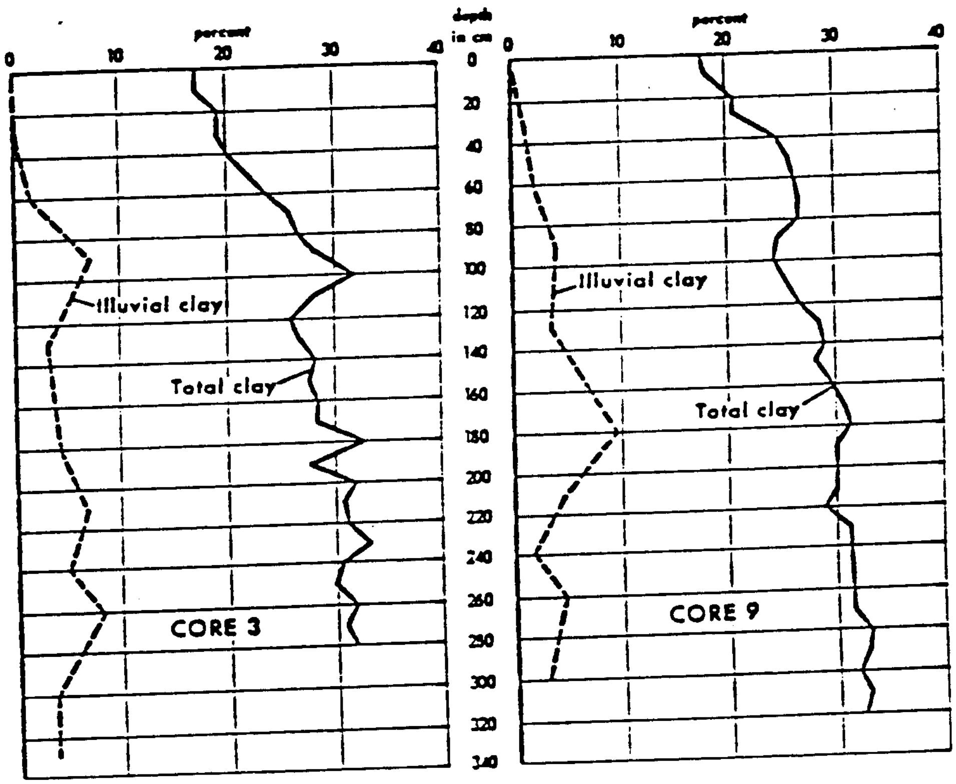

Figure 16. Vertical distribution of illuvial clay in profiles 3 and 9. The variation in the amount of illuvial clay, as estimated from point counts of the photomicrographs, is compared to the total clay profile. In profile 3 an increase in illuvial clay occurs at the same depth as the total clay increase which defines the argillic horizon. The point of maximum illuvial clay in profile 9 occurs below the modern B horizon (about 40-80 cm), but a slight increase occurs near the bottom boundary of the modern B.

Table 5. Percent of illuvial clay in profiles 3 and 9

Core No.	Depth	Total points with clay	Total points with voids	% clay
3	10-20	0	37	0.0
3	30-40	2	143	0.2
3	60-70	23	0	1.8
3	90-100	90	3	7.2
3	130-140	37	43	3.0
3	180-190	50	46	4.1
3	210-220	82	45	6.7
3	240-250	58	67	4.9
3	260-270	96	59	8.0
3	300-310	44	44	3.6
9	10-20	5	35	0.4
9	30-40	14	155	1.3
9	60-70	24	52	2.0
9	90-100	50	34	4.1
9	140-150	45	15	3.6
9	180-190	112	99	9.6
9	210-220	56	40	4.6
9	240-250	22	29	1.8
9	260-270	56	75	4.7
9	300-310	35	15	2.8

The amount of oriented clay, as estimated by this method, is considerably less than the total clay content of the soil. These results are consistent with other studies, which suggest that illuviation is not the only source of clay in argillic horizons (Oertel 1968; Brewer 1968; Bronger 1978). No standard method of distinguishing quantitatively between illuvial clay and other clay exists, but the presence of argillans containing oriented clay is accepted as qualitative evidence of illuviation (Thorp et al. 1957; Thorp et al. 1959; Buol and Hole 1961). Therefore, the combined evidence strongly indicates that clay migration has occurred, and probably is still occurring, in all profiles along the transect, and the subsurface clay-rich layer is a true argillic horizon. It is primarily on the basis of this horizon that the soil at this site is classified as an Alfisol.

6. Comparison of clay migration in profiles along the moisture gradient.

The nine profiles fall into three general categories on the basis of strength of argillic horizon expression. Defining criteria are depth to the upper boundary of the B horizon, distinctness of that boundary, and amount of clay in the B horizon. Profiles 6 through 9 have shallow but distinct argillic horizons, with clear upper boundaries between 30 and 50 cm down (Table 6). Clay contents at the maximum points are 27 and 28%. This contrasts with profiles 1, 2, and 3, which have maximum clay contents of 33, 28, and 32% respectively. The upper B boundaries are abrupt (profile 1) or clear (profiles 2 and 3) at 80-90 cm. Thus, soil profiles at both ends of the transect have good argillic horizons, but the "wet" end profiles show greater strength of development.

The middle profiles, 4 and 5, have 26% clay at the depth of maximum clay content. Profile 4 has an almost indistinguishable upper B boundary, falling somewhere between 20 and 65 cm. The boundary in 5 is more distinct, perhaps about 40-60 cm. These two profiles are the most weakly developed of any along the moisture gradient.

7. Relationship of the argillic horizon to the water table.

The relationship between the soil texture and the position of the water table shows that the area of greatest clay movement, profiles 1-3, coincides with the area of highest and most widely fluctuating ground water (Figure 17). Furthermore, the best argillic horizon development along the transect occurs in profile 1, at the "wettest" end of the gradient. Profiles 6-9 have B2t horizons located over 2 m higher than the mean position of the water table, and more than a meter above the highest level reached by ground water during the fall of 1978. The ground water probably rises to the modern soil in this area occasionally, but its influence on the modern B horizon appears much less pervasive here than it is in profiles 1 through 3, and probably 4 and 5 also.

Discussion

Differences in moisture characteristics, chemical properties, and horizon development were found along the 30 m transect at the Avery Bridge site. The north half of the transect, which is closest to the dolomite bluff, is within an area of high and fluctuating ground water. The water

Table 6. Argillic horizon properties

Profile No.	Depth to Upper Boundary(cm)	Distinctness of Boundary	Maximum % Clay Content
1	80	Abrupt	33
2	85	Clear	28
3	90	Clear	32
4	20-65	Diffuse	26
5	40-60	Gradual	26
6	50	Clear	27
7	30	Clear	28
8	50	Clear	28
9	40	Clear	27

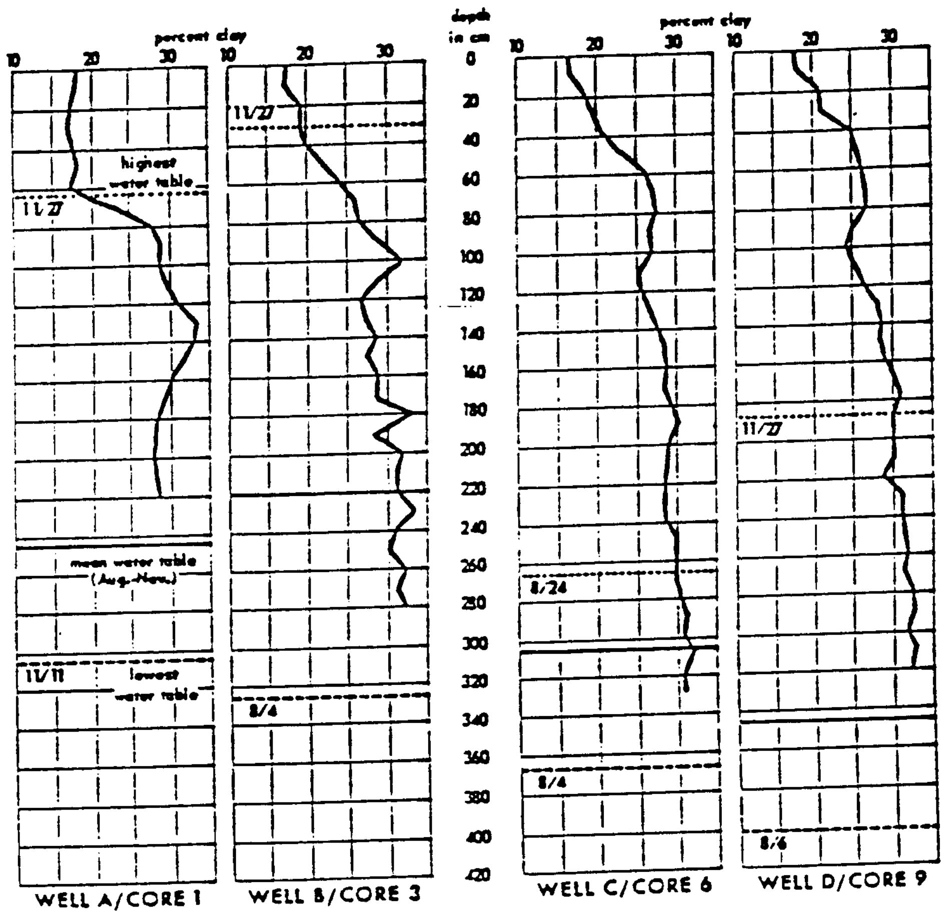

Figure 17. Relationship of the water table to the soil. Mean, maximum, and minimum water table levels are shown in relation to the clay profiles for soil profiles 1, 3, 6, and 9, which coincided with well locations. Values given are distances from the surface of the ground to the water table. During the measurement period, the water table rose to the modern soil only at the north end of the transect (wells A and B).

table slopes downward from this point, suggesting that ground water inundation of the upper part of soil is greatest at the north end of the transect and decreases toward the south end. The entire transect is affected by the water table, which rises with moderate and heavy rainstorms, but the water rises to the surface most frequently at the north end. It was hypothesized that greater migration of clay would occur in the area of most frequent rise and fall of the ground water, in which case the strongest argillic horizon expression should occur at the north end of the transect (profile 1), with horizonation decreasing in intensity toward the south end. In other areas this type of moisture regime has sometimes been found to be associated with more intensive migration of clay than occurs in comparable well-drained or poorly-drained soils (Daniels and Gamble 1967; Daniels et al. 1968; McKeague 1965). Translocation may be inhibited beneath the water table or in soil in which the water table remains near the surface for long periods of the year (Daniels et al. 1970; Daniels et al. 1971; Daniels and Gamble 1967; Daniels et al. 1968; Geis et al. 1970). When well-drained soils are compared to poorly-drained (but otherwise similar) soils, the consensus is that clay migration and horizonation are favored by good drainage, or greater depth of leaching, although poorly drained soils may have more clay in the B horizon and a more abrupt A/B boundary than well-drained soils (Goddard et al. 1973; Pomerening and Knox 1962).

Comparison of soils with low water tables with those subject to fluctuating ground water is inconclusive, some studies reporting greater and some lesser translocation in the well-drained soils (Daniels et al. 1967). The duration of saturation may be an important factor. Seasonally fluctuating ground water theoretically inhibits eluviation for the period during which the water level is high, while frequent, rapid rise and fall probably causes greater clay movement. At the Avery Bridge site the duration of the periods of saturation is probably hours or days, depending on the amount of precipitation, but the presence of seasonally high ground water seems unlikely. There are no soil characteristics at the site which suggest prolonged submergence. The comparison, therefore, is between a well-drained soil (profiles 6-9) and a moderately well-drained soil (profiles 1-3) with eluviation favored, not inhibited, by the ground water behavior.

The water table slopes downward in a southerly direction because precipitation is channeled from the surrounding area through the dolomite bluff to the north, and into the terrace sediment at this point. Karst springs of this type are very common in the Ozarks. The spring water seeps across and through the alluvium, creating the ground water conditions previously described. The spring water carries with it calcium and magnesium ions collected during its passage through the soluble dolomite. These adhere to the exchange sites on clay particles and enrich the soil solution as the water flows through the soil. The moving water also removes cations, so the condition of the soil at any time or place depends on the balance between leaching and replenishment. It was hypothesized that this addition of divalent cations would flocculate and immobilize clay, inhibiting the formation of an argillic horizon.

All exchangeable cations in the soil along the gradient are subject to leaching by precipitation falling directly on the field. Since precipitation is the same for all profiles, the intensity of leaching (as inferred by chemical properties of the soil) should be the same for all profiles unless another leaching agent is acting on some of them. The effects of leaching-by-precipitation are best examined in the soil least influenced by ground water (profiles 6-9), since

ground water is another agent causing leaching. These profiles are slightly acidic and have base saturation of 69-99% with 77-97% exchangeable divalent cations. Some of the cations have been removed by percolating rain water and the hydrogen ion has replaced them.

Since there is more moving water in the north end of the transect, because of the multidirectional flow of ground water, the soil at this end should have properties indicative of leaching equal to or greater than the "dry" soil in intensity. However, the reverse is true. The "wet" soil at the north end of the gradient is alkaline, with 100% base saturation and 94-98% exchangeable divalent cations, except in profile 1. That is, the soil with more water available for leaching has chemical properties which suggest that it is less leached than the soil with less percolating water. Addition of cations to the exchange sites to replace those lost to the moving water is the most reasonable explanation for this situation. The greatest loss of cations by leaching occurs in the seep area, but the lost cations are replaced by other magnesium and calcium ions, not by hydrogen. Therefore, the exchange sites remain saturated with bases and the soil remains alkaline in reaction.

The equilibrium between leaching and enrichment within the seep is probably not static but can be changed by any factor which changes the concentration of cations in the water. For example, the frequency, distribution, and quantity of precipitation, the residence time of ground water in the dolomite, the solubility of the dolomite, and the quantity and speed of flow of the ground water in the sediment could all affect the cation concentration and thus, the availability of divalent cations to the soil. Despite this situation, it is reasonable to assume that there are areas along the transect which most frequently experience net leaching, others which most frequently experience net enrichment, and a third group in which conditions of leaching alternate equally with conditions of enrichment. Profile 1 shows chemical properties which indicate net leaching, while profiles 2 through 4, and possibly 5, appear to experience enrichment at a rate equal to or greater than leaching. Minimal relacement occurs in 6 through 9, so net leaching is again indicated. However, these differences are relative; none of the profiles is markedly leached or acidic. All have very high base saturation and a high percentage of divalent cations. The differences in saturated flow of water for each profile are much greater in magnitude than the differences in chemical properties. Furthermore, although the soil within the range of ground water throughflow has a greater percentage of divalent cations than the rest of the soil, this defference represents a greater percentage of total divalent cations, not just calcium. Laboratory experiments suggest that magnesium, although it does flocculate clay, does not have as strong as inhibiting effect on mobility as calcium (Hallsworth 1963).

Profile 1, which is characterized by greatest amount of moving water and net leaching, has the best argillic horizon development. Profiles 6 through 9, which also have net leaching, but which collectively have the least amount of moving water of any of the profiles along the gradient, have good, but shallower and less developed argillic horizons. In other words, clay migration increases as the quantity of moving water in the soil increases, as suggested by the first hypothesis. Comparison of the two sets of profiles is complicated by the probability that some of the illuvial clay in profile 1 was carried in by laterally or upward moving ground water, while most of that in profiles 6 through 9 was undoubtedly moved down from the upper soil. This may account for the diffuse

lower boundary of the B horizon in profile 1. The clay distribution in 6-9 is more typical of argillic horizons formed by downward moving rainwater. The nature of the water table in the fall of 1978, however, clearly suggests that there is a strong downward component of water movement within the seep.

The association of greatest clay migration with greatest volume of moving water is not consistent all along the transect. If the central area is compared to the south end, the opposite conclusion is reached. Clay movement is least evident in profiles 4 and 5, although they are closer to the source of ground water than are profiles 6-9. The chemical properties of these two profiles are similar to those farther to the north. This, and the occurrence of the profiles along the middle of the sloping water table, is good evidence that ground water occasionally reaches the modern soil at this location. Presumably this occurs less often here than it does in adjacent soil to the north, but more often than in adjacent soil to the south. The conclusion, based on comparison of the central and southern profiles, is that clay eluviation is inhibited by high divalent cation content in the soil. This is in agreement with the second hypothesis.

Conclusion

In summary, the transect appears to be divided into three general sections on the basis of moisture, chemical, and horizon characteristics. The three sections are typified by profiles 1, 4, and 9 respectively, with the other profiles being transitional between the three groups. Group 1, or profile 1, is in the area most frequently saturated by ground water; is most highly enriched by calcium and magnesium, but loses some of these cations in the leaching process; and has the most strongly expressed argillic horizon. Group 2, or profile 4, is in an area still affected by ground water, but less frequently than group 1; is enriched by divalent cations to the point of total saturation of the clay exchange sites and, presumably, occasional enrichment of the soil solution by excess cations; and has the least strongly expressed argillic horizon. Group 3, or profile 9, is rarely affected by ground water; is rarely enriched by divalent cations, and is slightly more leached that group 1; and has an argillic horizon which is intermediate in strength of expression between groups 1 and 2.

This observed relationship between clay movement, moisture, and cations leads to the conclusion that clay eluviation does occur in a soil very high in calcium and magnesium, and increases in intensity as the amount of downward water movement in the soil increases. However, the evidence suggests that this occurs only after the divalent cations have been removed from the soil solution and have begun to be leached from the clay exchange sites (perhaps when base saturation falls below 100%). There appears to be a critical balance between the water and the concentration of ions which controls the formation of argillic horizons. That is, there is some point at which the tendency of excess water to move clays overcomes the tendency of divalent cations to immobilize them. This point is crossed twice along the Avery Bridge transect, once between profiles 1 and 4, and again between 4 and 9, such that only in the center of the transect is immobilization of clays by divalent cations an important factor in horizon formation. On either side of this area, there is enough water moving through the soil to reduce the amount of cations below the level at which significant immobilization occurs. Consequently, argillic horizons

have formed in pedons at the ends of the transect, their strength of expression dependent primarily on the amount of water moving downward through the soil profile.

The study of soil formation at the Avery Bridge site has several implications for paleoenvironmental reconstruction reasearch. It is clear that horizon development in pedons on a single geomorphic surface can differ significantly within a very small area. As similar sites are common in the Ozarks, and presumably in other areas with karst springs, the possible effects of spring water on the soil must be considered when sampling areas are selected or sediments analyzed. Sampling too close to a water source may yield strongly developed profiles, which may be interpreted as being very old or the product of a more humid climate. Similarly, a sample taken from the "edge" of a spring-affected area (or other source of divalent cations) may yield a minimally developed soil profile, also not representative of the surface as a whole. Sufficient, carefully chosen sampling sites must be examined before interpretations of the age of the soil/sediment or of the climate under which a soil formed, can be made. Analysis should be done with an awareness of the general and site-specific factors or processes (including competing processes) which have been important in the formation of the soil. The validity of any paleoenvironmental interpretation based on soils depends on the extent to which all these factors, as they affect the area in question, are understood.

Koch Spring Study Area

Koch Spring, on the lower Pomme de Terre River, is important to the Truman Reservoir Project in general, and to the soil geomorphic aspects of the project in particular. There are several reasons for this. First, Koch Spring proper is where some of the first 19th Century mastodon fossil discoveries were made. The fossils were subsequently displayed in travelling museum shows by Albert Koch (McMillan and Wood 1976). The area thus has important historic significance. Secondly, the Rodgers alluvium occurs in the area around the spring, where it has radiocarbon dated early, middle and late Archaic components. Third, Hapludalfs and Albaqualfs have formed in the Rodgers alluvium here and occur in close spatially related contexts similar to the Avery Bridge site but with the distinction that many of the pedons (the Albaqualfs) are much better developed. That is, they appear to be very high energy profiles, far more so than the most strongly expressed of the Avery Bridge transect soils (which were all Hapludalfs).

The area immediately south of Koch Spring on the T-1b terrace was identified as Rodgers alluvium on the basis of earlier soils mapping (Johnson 1977b; Johnson and Miller 1977) and from the geologic mapping of Haynes (personal communication, 1977; see also Haynes 1981). This area was selected for study for the reasons stated in the first paragraph. In 1977 Haynes had two backhoe trenches open in the area, one each on the Hapludalf and Albaqualf terrains (respectively trenches 78B and 78C of Haynes 1981); the soils and their geomorphic relations could thus easily be ascertained.

Purpose

The purpose of this phase of the soil geomorphic research in Truman Reservoir was to complement studies done at the Avery Bridge transect, to subject the energy model (Equation 4) to further scrutiny and testing, and finally to gain a better understanding of the nuances of alluvial soil formation in Osage Basin.

Methods of Study

Soils were field examined in and out of the two trenches 78B and 78C, and sampled at 10 cm depth intervals, with subsequent laboratory analyses (particle size analyses) run on the collected samples. Charcoal samples were collected for C-14 analyses at three levels in Trench 78B (40, 85, and 270 cm) by one of us (DLJ) and G.R. Brakenridge.

Results

Soil descriptions of both trenches plus laboratory particle size data are given in Appendix D. Figure 18 consists of percents of these textural data graphed together with soil horizons, artifacts, C-14 dates, and depth relationships.

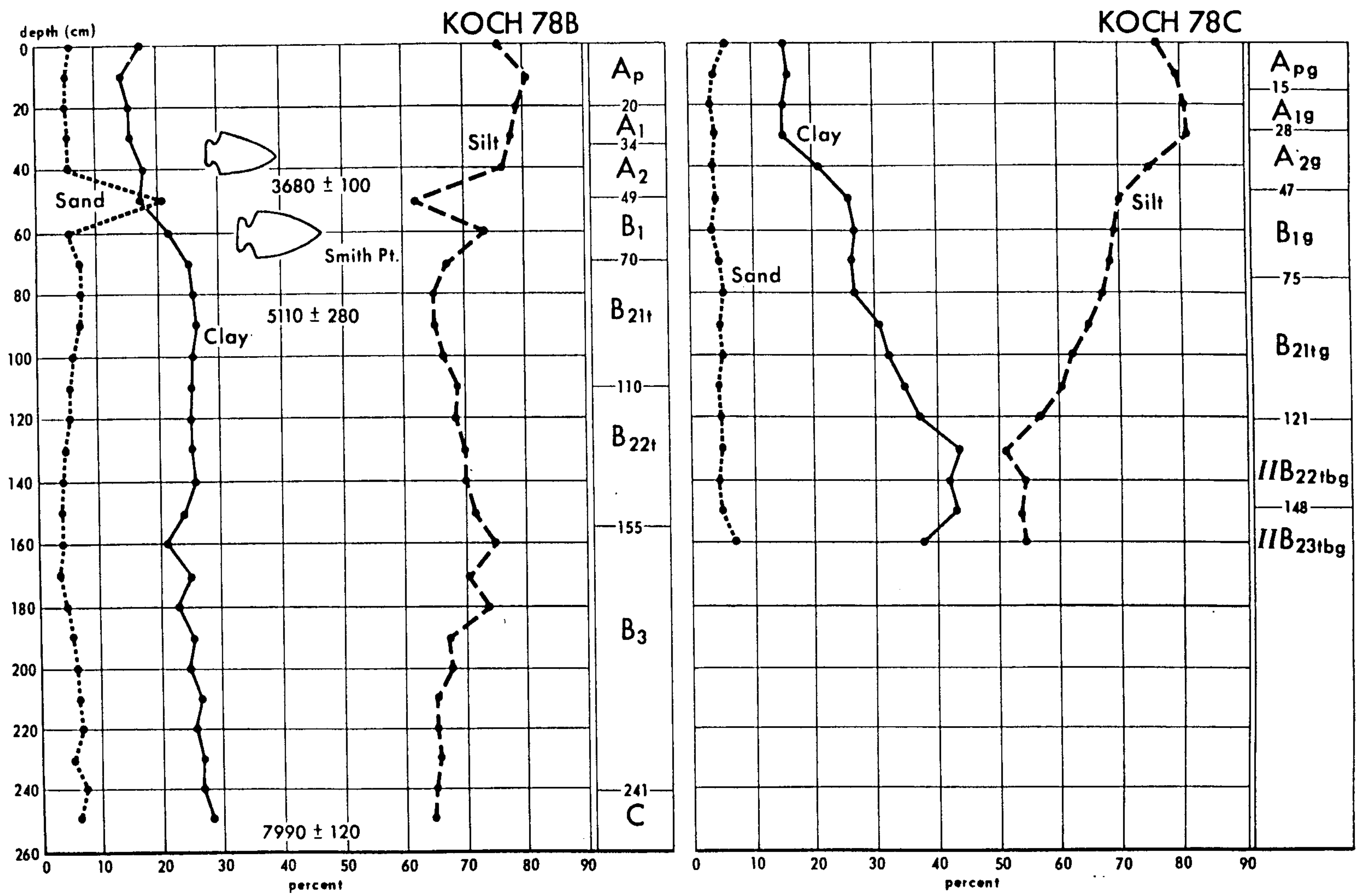

Figure 18. Soil morphology, horizon, texture, artifact, and C-14 relationship of soils and sediments developed on the Rodgers alluvium near Koch Spring, Pomme de Terre River, Missouri.

Discussion

The data shown in Figure 18 together with field relationships are interesting for a number of reasons. First, the parent material at 78C consists of approximately 1.2 m of Rodgers alluvium deposited over Koch alluvium. The latter buried alluvium has an upper layer which may be a soil (the IIB_{2tbg} horizons of Fig. 18) or, perhaps an alluvial clay layer. Clay content of this possible buried soil approaches 45 percent. The entire profile from the ground surface downward is gleyed and has low chromas (see soil description 78C in Appendix D).

The gleyed character of this soil (the entire polypedon exposed in the trench was observed to be gleyed) almost certainly reflects the high water table in the immediate area, for shortly after the trench was dug water began laterally seeping into it. The dense clay layer below 1.2 m irrespective of its origin, may also have induced gleying by restricting or inhibiting the downward flow of water. Another hypothesis is that the high water table enhanced the formation of this subsoil "clay pan," and that it is therefore neither a buried soil nor an alluvial clay layer. At any rate, irrespective of its formation, it presently probably inhibits downward flow of free water. In this regard, it is located at the toeslope of the bedrock valley sidewall which sheds surface and subsurface water run-on onto the site. The site is thus clearly a high energy area with respect to soil development. Abundant water is present which is, as indicated earlier, a potent organizing vector in soil formation (Equation 4). The C-14 date of 3,680 RYBP at 40 cm depth in trench 78B, several tens of meters away from 78C suggests that the upper 40 cm of Rodgers alluvium in the area was probably deposited during the interval 3700-1500 RYBP (Haynes' (1981) data indicate that Rodgers alluvium in the basin more or less ceased deposition by about 1500 RYBP). Thus the well developed Albaqualf at trench 78C appears to have formed very rapidly over a short period of time, probably in less than 3700 years.

Interestingly, the presence of slickensides in the IIB_{2tbg} horizons of 78C (see descriptions in Appendix D) and the virtual absence of field visible clay skins suggest that any clay skins that might be forming at present tend to be destroyed by argilliturbation as the soil alternately wets and dries via seasonal fluctuations of the ground water table. In fact, the presence of slickensides argues for periodic wetting and drying, and a fluctuating water table provides a subsoil environment conducive to the formation of "water table B horizons." This may account for the bimodal clay distribution in the B_{1g} and B_{21tg} horizons (47-121 cm) developed within the Rodgers alluvium portion of the profile, and may have been a clay enhancement factor in the Koch alluvium portion of the profile (i.e., below 121 cm).

The nearby Halpludalf polypedon at trench 78B, is not a run-on site, is much farther from the spring seeps and valley side walls, and is developed wholly in Rodgers alluvium, more than 2.8 m thick here. This soil is much less well developed, though for a Hapludalf it is still fairly well expressed (Fig. 18). In point of fact, this pattern in the Rodgers alluvium of strong profile expression at run-on sites versus relatively less expression at non run-on sites was consistently observed by Johnson and Miller (1977) during the soil mapping phase of the project.

Conclusions

The Koch Spring area provides another example where local conditions greatly influence the kind and rates of soil formation that can occur in parent material of the same or similar age. Inceptisols and Alfisols are the predominating soil orders that occur on the Rodgers alluvium (Johnson and Miller 1977) ranging from weakly expressed Eutrochrepts to strongly expressed Albaqualfs, as in Koch trench 78C. Again, strength of soil development in any given area may reflect either actual soil age, or predominating local conditions. Since assigning ages to soils and geomorphic surfaces is a principal task of soil geomorphologists, a careful consideration of all factors of soil formation in conjunction with an appreciation of various conceptual models of soil formation (Equations 1-4) is mandatory.

The Montgomery (Cut Bank) Site Study Area

The Montgomery Site is notable for having yielded over a number of years abundant Dalton component cultural materials which have been collected by various investigators (D. Roper, personal communication, 1978). The artifacts came from a layer some 3 m in depth within the Rodgers alluvium where it was being cut by a large meander loop of the Sac River near Stockton, Missouri (Figure 19). Charcoal collected from a reduced basal clay at 4.77 m depth gave a C-14 age of 9,800±120 RYBP (SMU-444).

Methods of Study

A T backhoe trench, dug principally for other purposes (see next section), was described and sampled to 3.6 m depth. The trench was emplaced a short distance from the cut bank and from the main Dalton exposure (Pedon A of Fig. 19). In addition, a 2¼ inch (7 cm) diameter core was hydraulically extracted in 4 feet lengths at a point immediately above the Dalton layer, passing through the layer, to a depth of 4 m. This core was placed in trays, wrapped with Saran, and transported to our laboratory at the University of Illinois. A second core was pulled from the same pedon (about 20 cm from the first), and described in the field (Pedon B of Fig. 19 and in Appendix E).

Chemical laboratory analyses were run on the samples from Pedon A at 10 cm depth increments. Particle size analyses were respectively carried out on Pedons A and B by the pipet and hydrometer methods.

Results

The descriptions of Pedons A and B are given in Appendix E along with the laboratory data. The particle size data, some of the chemical data, depths, horizons, archaeology, and C-14 relationships are graphed together in Figure 20.

Discussion

On the basis of the two pedons described and analyzed, and of the considerable time spent scrutinizing the cut bank exposure between the sampled pedons and on either side of them, some informed judgements may be made regarding the soils and the alluviational history at the Montgomery Site. These observations show that the Rodgers alluvium in this area is imperfectly drained, and has soils developed in it that range from Argiaquic Argialbolls (poorly drained Mollisols with strongly leached and bleached A_2 horizons, and clay rich B horizons) to Aquic Argiudolls (imperfectly drained Mollisols with weakly to moderately leached A_2 horizons, and clay rich B horizons). Interestingly, Pedon A, which is more strongly developed than Pedon B (see Fig. 20), is closer to a large spring seep, which occurs at the base of the Gravel Bluffs. A drainage ditch runs eastward from Gravel Bluffs across the T-1b terrace here. The soil exposed in the ditch showed increasing development with nearness to the spring seep (whiter, thicker albic horizons, stronger argillic horizons, abrupt horizon boundaries). Clearly there is a high energy gradient towards the spring, which fits the oft-mentioned energy-soil development pattern observed for the Osage Basin in general.

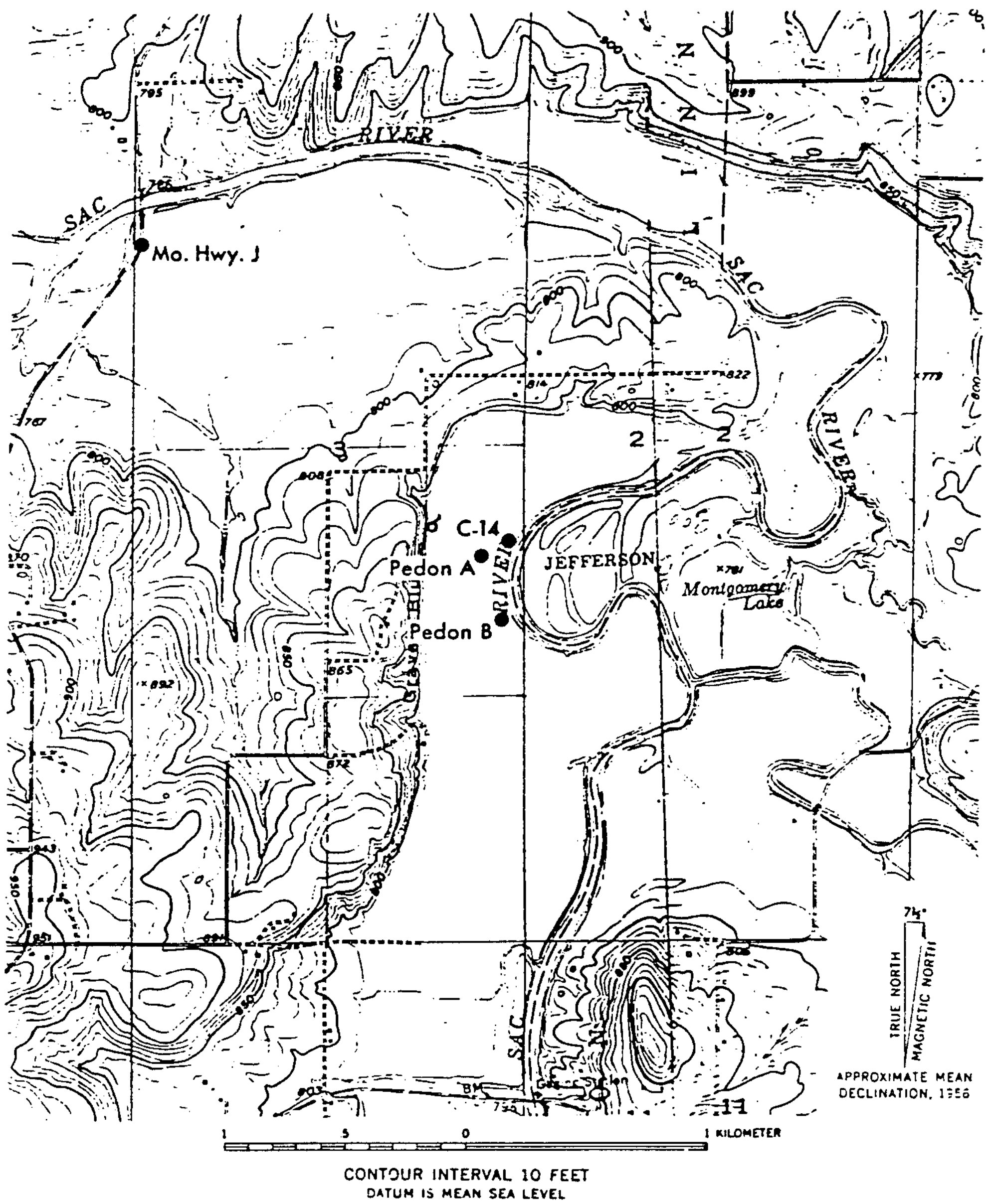

Figure 19. The Montgomery Site near Stockton, Cedar County, Missouri. Locations of the C-14 locality, spring seep, and pedons A and B are as shown. The pedons occupy positions on the broad T-lb terrace that occurs here.

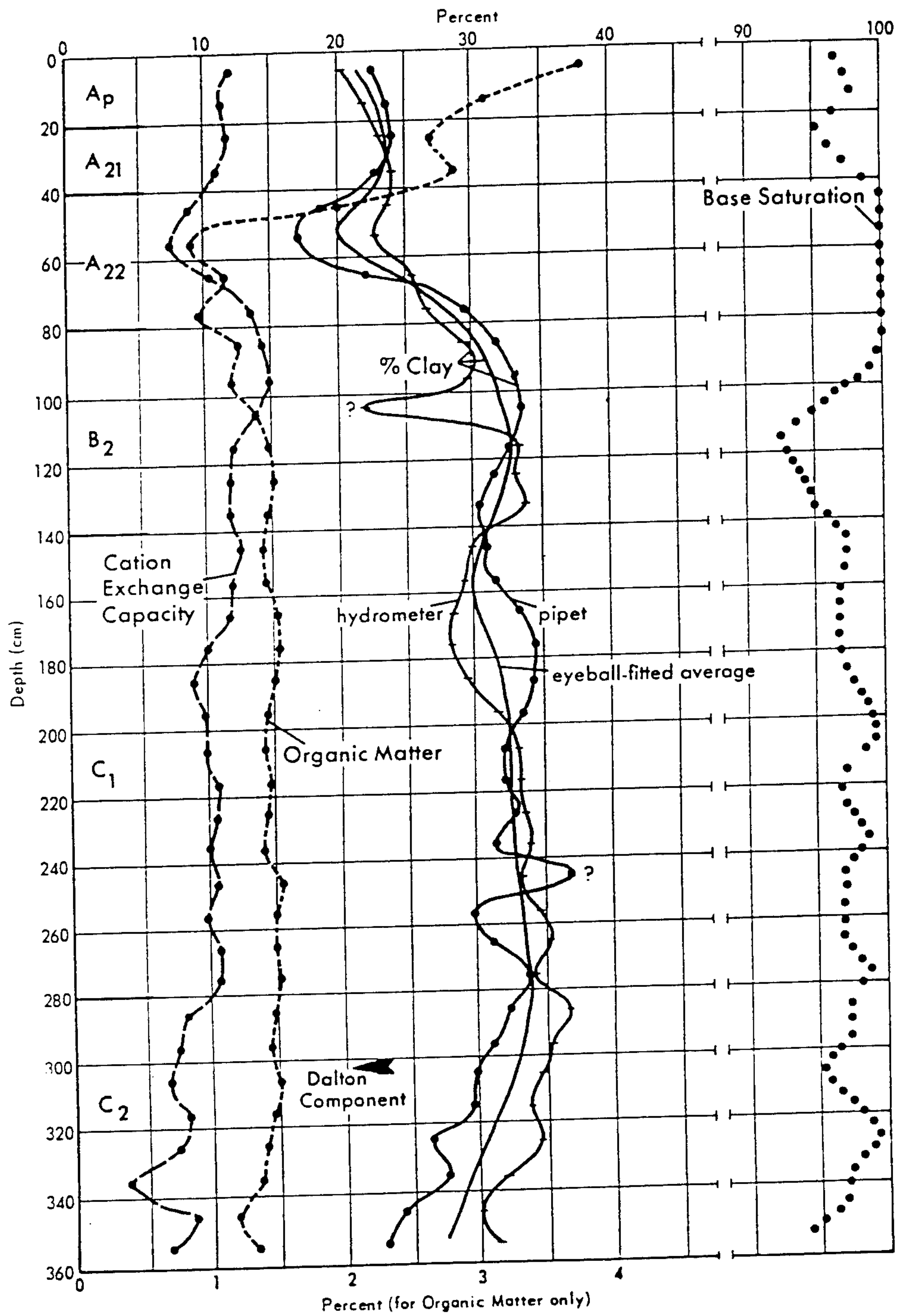

Figure 20. Soil particle size and chemical data, depth, horizon, artifact, and C-14 relationships at the Montgomery Site, Sac River, Missouri.

The descriptions and particle size data show that considerable clay occurs as a broad secondary bulge below the modern, present argillic horizon, between 160-300 cm depth. This clay bulge may be either of alluvial, illuvial, or of in situ weathering (or some of all three) origin. However, the presence of clay skins in this layer indicates that at least some of the clay is illuvial. The bulge may represent a prolonged period of pedogenesis. The clay decrease between 140-160 cm may be a former A_2 horizon. This interpretation is strengthened by the presence of abundant silt coatings (common in modern A_2 horizons) in the soil matrix in this interval (the present B_{3g}). Conversely, the secondary clay bulge might reflect slow, intermittent alluviational episodes that alternated with soil forming episodes. If so, the 140-160 depth interval may represent a period of fairly active alluviation and minimal pedogenesis. In light of the evidence for a modest period of soil formation elsewhere in the Osage Basin, for example, at the top of Stratum 2 in Rodgers Shelter, and evidence for a presumed equivalently developed soil buried at Avery Bridge, the former is the preferred interpretation.

Conclusion

The modern soil developed in the Rodgers alluvium in the vicinity of the Montgomery Site ranges from well developed Argialbolls to moderately developed Argiudolls. The former are high energy profiles where strength of development is positively related to increasing moisture availability. A secondary subsoil clay bulge may be explained in several ways, but the presence of illuvial clay in an inferred buried argillic horizon, and the presence of silt coatings in a possible super-jacent buried albic horizon, collectively suggest that a roughly mid Holocene episode involving cessation of alluviation and concommitant soil formation occurred.

Wolf Creek and Hand Sites

Because of priority concerns for meeting the timetable for our principal stated (proposed) research objectives in other parts of the Osage Basin, only very limited soil geomorphic investigations (mainly advisory to D. Roper) were able to be carried out at the Wolf Creek and Hand sites. The Wolf Creek Site is notable for its Archaic and possibly paleo-Indian components, and the Hand Site for a paleo-Indian projectile point found by one of D. Roper's archaeological survey crew members. Samples were collected, and some analyses were run (particle size, pH, and some aspects of clay mineralogy). For the record, only the particle size data for both sites are presented here, in Appendix F (the pH results were problematic, and the clay mineralogy data, when completed, will be published at a later date.

The Wolf Creek Site is also notable for the presence of two buried soils. This is the only alluvial sequence observed to have more than one buried soil with the exception of the Rodgers Shelter sediments.

Weakly Developed Buried Soils (and their rarity) in the Rodgers Alluvium

Introduction

While assessing the stratigraphy of Rodgers Shelter in the late 1960's and the 1970's, various investigators, including the present authors, noted the presence of several weakly developed buried soils and one moderately well developed (in Stratum 2 and at its base[5], respectively), in the Rodgers alluvium under the Shelter (Ahler 1973, 1976; Haynes 1976, 1981; Kay 1980; McMillan 1971; and Kay, Personal Communication 1981). A soil within an alluvial sequence is normally interpreted as indicating a significant reduction or cessation of alluviation followed by or concommitant with an episode of soil formation. Such a period of "stability" is usually interpreted to be causally related to climatic or environmental stability. (The modern soil in the Rodgers alluvium is the best analog, having formed during the present stable period.) Further, since most alluvial deposition appears to be episodic through time, it therefore seems conceptually reasonable to expect that discrete incipient soils, along with perhaps one or two moderately developed ones, should have developed. Using this rationale, it was assumed in the early phases of this study that any stability episodes (and likewise any antecendent and later unstable episodes) would have been regional in extent. Therefore, both weakly and moderately developed soils should occur as chronologically similar marker horizons elsewhere in the Rodgers alluvium. One of the several purposes of the soil geomorphic aspects of the Truman Reservoir Project was, consequently, to test the validity of these assumptions.

Methods

Several strategies were employed. First, recognizing that some buried alluvial soils are difficult to perceive in the field due to certain post-burial processes (e.g., clay illuviation from above, pedoturbation, etc.), a 3 m deep 'T' pointed south) was cut in Rodgers alluvium in the field in which the Montogomery Site occurs (Pedon A of Fig. 19). The orientation of the trench was planned so that the south-facing wall would be sun-illuminated for photographic purposes. The walls of the trench were carefully examined for evidences of alluviational pauses such as organic-rich layers, concentrations (bands) of oriented clay and other evidences of buried soils. The nearby natural cuts in Rodgers alluvium along both the Sac and Pomme de Terre rivers were also carefully examined for such features.

The south facing sun-lighted wall at the top of the 'T' trench was trowelled smooth and allowed to dry for several weeks. The idea behind this activity was that any illuvial clay band not initially apparent would ultimately shrink and crack upon drying, and would then be seen. Thin sections made of clods within and immediately above and below such a band would, under microscope examination, verify the presence or absence of concentrations of oriented clay, and thus the presence or absence of a buried soil.

Another strategy employed was to systematically core the Rodgers alluvium and, in the same fashion as above, carefully examine the extracted cores for

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[5]Near or at the top of Stratum 1, according to Kay, this volume.

visual evidence of pedogenetic zones. This was done to a limited extent along the Sac River, and to a much greater extent in the Big Bend area immediately upstream from Nigger Spring on the Pomme de Terre River (see Miller 1982), and at the Avery Bridge transect (see Watson-Stegner 1981, and this study).

A third strategy was to subject samples collected from various profiles in Rodgers alluvium to laboratory analysis in hopes of physically or chemically detecting any buried soils that might be present.

A fourth strategy was to carefully search for buried soils in all the backhoe trenches cut in the Rodgers alluvium that were established for other purposes (e.g. trenches 78B and 78C of Haynes 1981, and the Avery Bridge transect of Watson-Stegner 1981 and this study).

Results

The results of the 'T' trench study were inconclusive. No field evidence of pedogenic banding was observed, and no cracking bands were seen other than the modern subsoil (B_{2t}) horizon. Likewise, unequivocal field evidence for concentrated shrink-cracked illuvial clay bands was not observed within the Rodgers alluvium per se in the natural cut bank exposures along either the Sac or Pomme de Terre Rivers, or in trenches 78B and 78C, near Koch Spring or in the Avery Bridge transect trench, or in the many cores pulled from the Rodgers alluvium elsewhere.[5] However, abundant silt coatings from a possible buried albic horizon were recorded at the Montgomery Site at 140-160 cm depth as mentioned in an earlier section (see also description of Pedon A in Appendix 6). Laboratory analyses on the other hand, proved more interesting. They strongly suggest for example, that a moderately well developed buried soil exists along the Avery Bridge transect and at the Montgomery Site. The evidence is in the form of a pronounced secondary subsurface accumulation of illuvial clay (determined by particle size analysis in both areas and, in the case of Avery, by thin section micromorphologic studies - see Figure 21, and micromorphological data in Appendix B, and Watson-Stegner 1980). However, no unequivocal incipient or weakly expressed buried soils were detected anywhere, which was unexpected.

Discussion

A dilemma thus exists. Other than the exception at Wolf Creek, discrete moderately developed buried soils occur in the Rodgers alluvium at Rodgers Shelter, at Avery Bridge, and at the Montgomery Site, but incipiently developed soils appear to be absent or not recognizable even at those sites where intensified field and laboratory studies have been conducted. Why? The question is especially central considering the fact that the Rodgers alluvium was deposited over approximately 9,500 years (ca 11,000 to 1500 RYBP) so that one would reasonably expect at least several short episodes of alluviational cessations and concommitant soil forming periods to have occurred.

The problem may be reasonably explained in several ways. One is that when incipient pedogenesis occurs in episodically accreting alluvial units the pedogenetic traces become subsequently masked, following burial, by

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[5]An important lone exception is the Wolf Creek Site, where two buried soils occur, one moderately developed, one weakly developed.

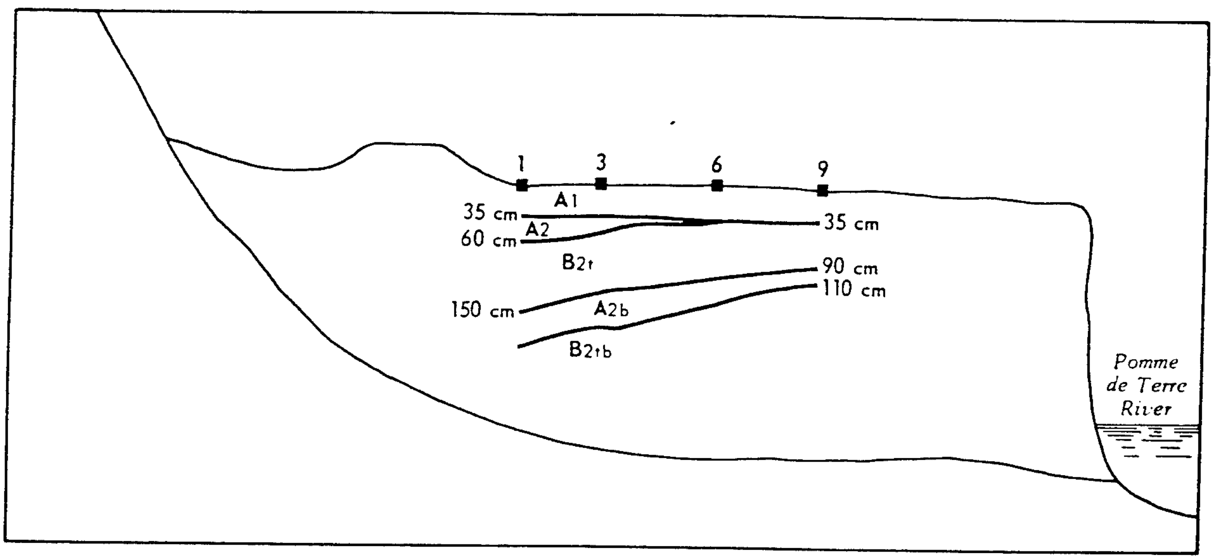

Figure 21. Relationship of surface and buried horizons (including their thickness and depth) along the energy gradient at the Avery Bridge transect. The horizons thicken and deepen, and the profile becomes better developed with nearness to the energy source (i.e., the spring seep to the left). (From Watson-Stegner 1980).

through-going pedogenesis from above. Individual weak illuvial clay bands or minimally developed A_2 horizons would thus be blurred and masked as the profile builds episodically upwards. On the other hand, well developed soils upon being buried should retain some of their morphological characters, such as a recognizable argillic or albic horizon, or some manifestation of these horizons (oriented illuvial clay, in the case of the argillic horizon, and silt coatings in the case of the albic horizon). Such is the case with the Stratum 2 soil in Rodgers Shelter, the buried soil at Avery Bridge, and the presumed buried soil at the Montgomery Site.

Another explanation is that some of the older Rodgers alluvium components that may have contained weak soils may have been removed by erosion. Haynes (1981) recognizes six episodes of cutting and filling in this unit (R_1 through R_6 of his Fig. 3) the oldest of which (R_1) has presumably been removed in most areas, a presumption based on its scarcity.

Conclusions

The presence of weak buried soils developed in alluvium in Stratum 2 in Rodgers Shelter, and their apparent absence in similarly aged alluvium elsewhere in the drainage basin[6] suggests that either (1) alluviational hiatuses with concommitant pedogenetic episodes may not be regional in extent, or (2) part of the alluvial-pedogenetic record is missing or totally masked. With regard to (1), the weakly developed soils in Stratum 2 may reflect some environmental circumstance that either is site specific or localized to a certain stretch (or stretches) of a river. If so, then our original assumption about regionality of environmental events is wrong. Likewise, with regard to (2) it is difficult to conceptualize how a river could episodically cut out chronologically long alluvial components that contain discrete pedogenetic traces, and replace them seemingly everywhere with younger Rodgers alluvium

The explanation that we prefer is the one articulated above, that unless a lengthy stable period of non-alluviation allows a moderately strong soil to develop, weak soils will be blurred by pedogenetic forces that follow burial. (The preservation of weak pedogenetic traces at the Shelter may reflect preservational factors that were site specific to the "sheltered" environment of Rodgers Shelter). This model explains how and why moderately to strongly developed buried soils occur, and why weak ones either don't, or are rare.

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[6] Except at Wolf Creek (see footnotes).

The Distributional Abundance and Thickness of Clay Skins Versus Soil Profile Depth

In the earlier soil mapping phase of the Truman Reservoir Project, and during the present soil geomorphic phase, a fairly consistent pattern in the Rodgers alluvium was observed whereby clay skins were most abundant (but thin) in the B_{2t} horizon of the modern soil, and least abundant (but thickest) in the C horizon (see for example Pedon B description, Appendix E). A search of the literature yielded little that clearly alluded to such patterns elsewhere. One of us (DLJ) has observed the same pattern in coarse and fine grained alluvial soils in coastal California (Johnson 1980, Keller et al. 1980, 1981a, 1981b).

Although a fully controlled and focussed investigation into the problem could not be integrated into our research design due to time constraints, considerable thought and hypothesis juggling was given to the matter, the results of which we briefly articulate here.

Figure 22 represents a hypothetical Hapludalf profile developed on the Rodgers alluvium in which only macro-voids (ped interfaces and bio-channelways) are emphasized. Although hypothetically presented in the figure, this pattern was clearly apparent in the Rodgers alluvium at the Montgomery Site on the Sac River, and observed along the bluffs of the Pomme de Terre River at the Avery Bridge site. The following model is offered to explain the pattern.

The greatest observed population of macro-voids in many if not most modern soils is along ped interfaces in B horizons, especially during dry periods when the subsoil shrinks and cracks. The average depth to which most growing season wetting fronts penetrate tends to be the middle of the B horizon. Respiring vegetation quickly absorbs new moisture and thus plays a pivotal role in slowing or stopping wetting fronts. Since downward-moving soil water nearly always contains suspended clay, its general Gaussian distribution in modern argillic horizons (Figs. 15, 20) is thus essentially predicted. Some of this clay invariably is of the high shrink-swell Smectite group. As it accumulates in the subsoil, the latter begins shrinking and swelling in conjunction with dry and wet periods, the degree of shrink-swell being commensurate with the amount of clay present. This activity together with ped disruption via growing plant root and other vectors disrupts clay skins, whose remnants become matrix clay in new peds.

During non-growing cool seasons, however, when transpiration ceases and evaporation is ineffective, wetting fronts pass through the B and penetrate the C horizon. This happens occasionally even during the growing season when precipitation is excessively heavy. Further, there are fewer roots to extract water in the C horizon. Clay in suspension is not deposited in macro-voids between peds, as in the B, because there are none. Instead, it is deposited in the vertical cylindrical bio-channelways down which the soil water and its suspensions pass. Because the C horizon remains moist, it escapes the shrink-swell effects felt higher up. Clay skins thus are preserved, and grow thicker with time. The result is the pattern of clay abundance and thickness shown in Figure 22.

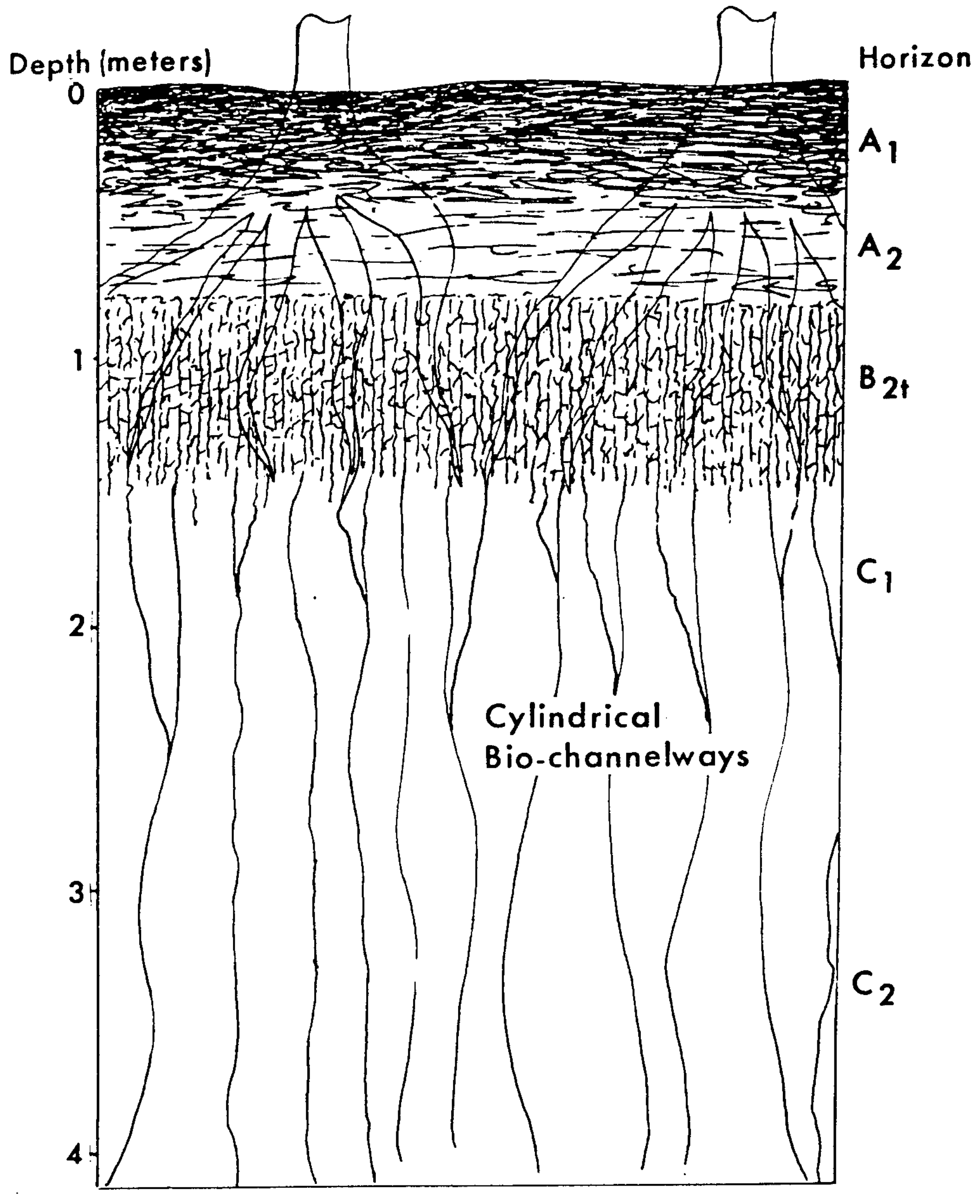

Figure 22. Hypothetical deep soil profile showing macro-voids down which "wetting fronts" move. The abundance of macro-voids in the argillic horizon evolved with the horizon and is due to illuvial clay accumulation over time, and to shrinking and swelling of the clay associated with alternate wetting and drying episodes during growing seasons (see text for discussion). Though illuvial clay accumulates, clay skins tend to be destroyed and to reform through time.

Macro-voids in the lower profile are far fewer in number and form in cylindrical bio-channelways. Due to lack of turbations at depth clay skins are preserved within them.

Chapter Four

CONCLUSIONS

Chapter Content

This chapter pulls together the seminal points and conclusions established in this study, and examines whether they may be applied to the entire Osage Basin, other parts of the Ozarks, and the Midwest in general. The chapter concludes with a brief discussion of further work that remains.

Discussion and General Conclusions

Loess-derived silt has been an important contributor to the upland and bottomland soils, as well as the alluvial units in the Osage Basin of Missouri. The principal loess source was from the Missouri River to the north. The loess is thickest on the bluffs adjacent to the river and thins southward. In some areas it appears to have been largely removed by erosion from certain interfluves (MLT 9-10, and 13) but is present in abundance in others (MLT 12, 14), which includes the Pomme de Terre drainage basin.

One of the most important Holocene-age alluvial units in the Pomme de Terre valley, the Rodgers alluvium, is dominated by silt size sediments that are largely re-worked Peorian loess. In fact, the Rodgers alluvium owes its brownish color to the original color of this loess. The blackish Pippins alluvium, a younger late Holocene unit that comprises the modern floodplains (first and second bottomlands), is also interpreted as being largely of loess origin, but whose sediments had a longer residency period on interfluves, and became, therefore, more humified and darker. Whereas landscape instability associated with concommitant interfluve erosion and Rodgers alluvium deposition is interpreted as being climatically induced, instability associated with stripping and the deposition of Pippins alluvium is believed to reflect cutting, clearing and burning of the river basins by late Holocene Woodland Indians. Charcoal, more abundant in the Pippins than the Rodgers alluvium, may reflect these activities and possibly may have contributed to the darker color of this alluvial unit.

Soils showing different degrees of development are common on alluvial units of like or similar age in the Osage Basin. This pattern is partly due to complex cut and fill sequences occuring at different times that characterize alluvial units in general, the Osage Basin notwithstanding (Haynes 1981), but it is also partly due to certain local conditions that promote accelerated pedogenesis. Energy in the form of free water is a powerful pedogenetic organizing force. In the three areas most intensively studied, Avery Bridge, Koch area, and the Montgomery Site, a clear relationship exists between increased profile development and nearness to a spring seep or water source. Watson-Stegner (1980), however, showed that the quality of the water is as important as its quantity.

Radiocarbon dates and stratigraphic-archeologic relations at the three sites indicate moderately and strongly developed profiles, such as Hapludalfs and Albaqualfs, can form in less than about 3600 years.

Moderately well developed buried soils formed in the early to mid Holocene occur at the Wolf Creek Site, in Rodgers Shelter, at Avery Bridge, and at the Montgomery Site. We provisionally conclude that these soils are chronological and synchronously correlative, and that they reflect a regional episode of environmental stability, with concommitant cessation of Rodgers alluviation and soil formation. We further conclude that the apparent absence of a suite of weakly developed intercalated soils (conceptually expected in episodically aggrading alluvium) in almost all areas of the Rodgers alluvium except Stratum 2 in Rodgers Shelter, reflects post-burial blurring of pre-existent pedogenetic traces via soil formational processes from above.

We further provisionally conclude that the observed pattern in the Rodgers alluvium whereby clay skins are most abundant but thin in modern argillic horizons, and least abundant but thickest in the C1 and C2 horizons, is due to the complex effects of (1) moisture extractive vegetation; (2) the alternate wetting and drying of argillic horizons during the growing season; (3) the presence of abundant interpedal macro-voids in argillic horizons; (4) the on-going destruction of clay skins in argillic horizons via shrink-swell and other turbations; (5) the preservation of clay skins in C horizons because turbations are absent there; (6) the concentrated flow of water at depth along a low population of cylindrical bio-channelways; (7) occasional wetting episodes that occur during the non-growing season; (8) and excessive wetting episodes that occur under saturated soil conditions during the growing season.

Applications of These Models and Concepts to other Areas of the Ozarks and Midwest in General

The recognized presence of the Rodgers alluvium, or Rodgers-like alluvium, at a number of sites scattered all across Missouri (Fig. 1), perhaps including the Ouachitas to the south (Fig. 2), indicates, and we conclude, that the paleoenvironmental processes that were operating between about 11,000 to 1,500 years ago were generally regionally synchronous. Therefore, the same general conclusions and alluvial-soil-stratigraphic models presented here should be applicable throughout Missouri in particular, and the Midwest in general, possibly including the Ouachitas to the south. This generalization should be tempered, however, with the observation that the Rodgers alluvium seems not to occur east of the Mississippi River in central and southern Illinois (L. Follmer, personal communication 1981). Further work is obviously needed here.

Predictive Applications in Archeology

As suggested in earlier reports (Johnson 1977a, 1977b, 1981a) soil-archeologic-alluvial-stratigraphic relationships established by the authors and other workers (Haynes 1976, 1981) can be used for general archeological predictive purposes. These are worth restating here.

Archaic and Paleo-Indian cultural materials will not be found <u>in situ</u> in the Udifluvents and other soils developed in the T-0 sediments (Pippins alluvium) of the Osage River Basin unless the material is reworked and secondarily deposited or is intrusive by later Indians. Likewise, no Woodland materials except intrusive elements may be expected within Eutrochrept-Hapludalf profiles other than in the upper 25 to 50 cm or so (mainly the plow zone). The mapped and described Eutrochrept-Hapludalf-Albaqualf-Argialboll-Argiudoll complex in the study area is comprised of Holocene-aged soils developed in Rodgers alluvium which, as mentioned earlier, began accumulating about 11,000 years ago, and ceased accumulating (except for occasional overbank depositions) about 1,500 years ago (Ahler 1976; Haynes, this volume). The upper 25 to 50 cm (approximately) of sediments are post-1500 B.P. overbank floodplain deposits. Woodland materials may, of course, be expected in the plow zone of <u>any</u> soil in the study area.

Future Work

Although this and other studies (Miller 1982), including those in this volume, collectively represent a tremendous step forward in our knowledge of the physical environment, paleoecology, and human adaptations to the Ozarks area, further work still needs to be done. Our conclusions that the models and relationships between soils, sediments, archaeology, and chronology established for parts of the Osage Basin are applicable throughout the entire Osage Basin, and throughout the Ozarks in general, and possibly the Ouachitas, need further testing and confirmation (or rejection). Why, for example, do these relationships appear not to apply east of the Mississippi River in Illinois?

Further work also needs to be done on the distribution and dispersion of loess in Missouri. More transects need to be run, and further minerological work is desirable on various loess silt fractions (being carried out by DLJ at this writing).

A great deal of further work also needs to be done on pedogenetic models vis-a-vis alluvial and other soils.

Finally studies similar to this one, and to others in this volume, conducted in other drainage basins in the Midwest (e.g., southern Illinois?) would be highly desirable and should yield very fruitful cross-comparative information on prehistoric environments and how humans adapted to them.

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1980 Soil development in Holocene-age alluvium on the Pomme de Terre River, Missouri. Master's thesis, University of Illinois, Urbana. 113p.

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1975 Conceptual models in pedogenesis: can soil-forming functions be solved? Geoderma 14:189-205.

Appendix A

This appendix contains a list of all completed or in progress theses papers read, published works, unpublished reports, and papers in preparation that are partly or wholly related to soil geomorphological work done on the Truman Reservoir Project.

Theses

Miller, M.V.
(n.d.). Soil Geomorphological investigations and soil development sequences on Pleistocene and Holocene alluvial terraces, Big Bend, lower Pomme de Terre River, Missouri. Ph.D. thesis, University of Illinois, Urbana (in prep.).

Watson-Stegner, D.
1980. Soil development in Holocene-age alluvium on the Pomme de Terre River, Missouri. Master's thesis, University of Illinois, Urbana. 113p.

Papers Read

"Soil-Mapping, Soil-Geomorphic Relationships and Terrace Sequences, Western Ozark Highlands, Missouri." Presented at the 9th Congress of the International Association of Sedimentologists, Israel, July 9-14, 1978 (D.L. Johnson and M.V. Miller).

"Soil-Geomorphic and Soil-Archaeologic Relationships, Osage River Basin, Western Ozark Highlands, Missouri." Read in the Symposium "Paleoindian to Plainville: Holocene Adaptation in the Truman Reservoir, Southwestern Missouri" at the 43rd Annual Meeting of the Society for American Archaeology in Tucson, Arizona, May, 1978 (D.L. Johnson).

"Soil Genesis in Recent Alluvium in Southwest Missouri. Read at the Association of American Geographers National Meetings in Philadelphia, April 22-25, 1980 (D. Watson-Stegner).

"Time and the Argillic Horizon: A Comparison of Rates of Argillic Horizon Formation in Different Climates." Read at the Association of American Geographers National Meetings, Los Angeles, April 19-22, 1981 (D.L. Johnson).

"Soil Genesis on Terraces of the Pomme de Terre River, Southwestern Missouri." Read at the Association of American Geographers National Meetings, Philadelphia, April 22-25, 1979 (M.V. Miller).

Published Works

Graham, R.W., C.V. Haynes, Jr., D.L. Johnson, and M. Kay
1981 Kimmswick: A Clovis-mastodon association in eastern Missouri. Science 213:1115-1117.

Johnson, D.L., and M.V. Miller
1978 Soil mapping, soil-geomorphic relationships, and terrace sequences, western Ozark Highlands, Missouri. Tenth International Congress on Sedimentology Abstracts 1:339-340, Jerusalem.

Unpublished Reports

Soils and soil-geomorphic investigations in the lower Pomme de Terre valley. In Cultural Resources Survey, Harry S. Truman Dam and Reservoir Project, vol. 10, pp. 59-139. Department of Anthropology, University of Missouri, Columbia (D.L. Johnson). 1977.

Soils of a selected part of the lower Pomme de Terre River, Hickory and Benton Counties, Missouri. A soils map produced for the University of Missouri, and the U.S. Army Corps of Engineers, Kansas City District. 1977 (D.L. Johnson and M.V. Miller).

Upublished Reports (cont.)

Geology of the Sohn Archaeological Site, Little Blue River, Missouri. U.S. Army Corps of Engineers Contract Report on the Sohn Site, Missouri, Missouri Highway Department, Columbia, MO. (D.L. Johnson) 1977.

Soil Geomorphology of the Kimmswick Clovis-Mastodon Site, Missouri. Report to the Illinois State Museum, Springfield (D.L. Johnson and D. Watson-Stegner) 18p., 1981.

Soil Geomorphic Investigations at the Bug Hill Site (34PU116), Clayton Lake, Oklahoma. Report for the Army Corps of Engineers, Tulsa District, Tulsa, Oklahoma. 37p. (D.L.Johnson) 1981.

Soil Geomorphological and Alluvial Stratigraphical Overview of the Feeler Site (23MS12), Central Gasconade River, Missouri. Report for American Archaeology Program, Department of Anthropology, University of Missouri, Columbia. 13p (D.L. Johnson) 1981.

Papers in Preparation

A north-south loess transect in west central Missouri (D.L. Johnson and P. Wilcock).

Soil Development and energy models in the Osage Basin, Missouri (D. Watson-Stegner).

Time and argillic horizon development in Holocene alluvium, west central Missouri (D.L. Johnson and D. Watson-Stegner).

The Rodgers alluvium: a major marker unit in midcontinental North America (D.L. Johnson).

Appendix B

This appendix contains miscellaneous data pertaining to the loess transect discussed in Chapter 2.

Summarized Particulars of the Waverly-to-Wheatland Loess Transect

Sampling Dates

Sample No.	Sampling date
MLT 1-4	8/3/77
56	8/6/77
7-10	8/5/77
11-14	8/4/77
Lost Hill	7/30/78

Sample locations

All sampling locations are shown on Figure 3 of text. Legal descriptions of the locations are given in the profile descriptions which follow in this appendix. All samples were taken on interfluves with <2 percent slopes, except Lost Hill with a 3-5 percent slope.

Particle size analysis

Beyond that discussed earlier in the Methods of Study section of Chapter 2, the following was done.

A standard was run in the pipette analysis for each set of ten samples. The results are as follows:

Fraction	> 50μ	50-20μ	20-5μ	5-2μ	< 2μ	50-2μ
Mean %	6.66	26.05	32.14	6.72	28.44	64.90
Std. Dev.	0.18	1.53	1.87	1.26	1.31	1.32

The number of standards run was 22. Average values for the same standard run on only one pipetting of sand, silt and clay by M. Miller in our lab are 6.7% sand, 64.4% silt and 28.8% clay. The standard deviations of the standards used here are larger than Miller's. There are two possible explanations, operator error and/or the effect of two additional pipetting per sample with the method used in the present study (thus disturbing the sample twice before the clay pipetting is made). The variations in the data presented here, however, are judged to be small enough that conclusions drawn from it are accurate (e.g. a sand increase of 0.2% due to experimental error would not trigger an erroneous conclusion; we would expect a much larger valve to identify a change in parent material).

One standard was inaccurate (lab #5) and lab samples #1-10 may possibly be in error. These are samples MLT6 240-407 cm. Due to time constraints they have not been redone. While these samples undoubtedly contain interesting information, it is probably possible to ignore them in the context of this project as there seems to be a clear break from a silty eolian mantle to a sandier material and paleosol at 120 cm. of depth.

Profile descriptions

Descriptions of samples MLT 1-14 were made during fall, 1977, by P. Wilcock, and are given below. They were based on examination of 5.7 (2¼ inches) diameter cores pulled with a truck-mounted hydraulic Giddings coring rig.

They contain certain descriptors (notations, symbols) that describe attributes of color, texture, structure, consistence, boundary conditions, and mottles, in that order. The meaning of these notations may be found using the keys on this page. Examples are as follows:

Color: Moist colors (unless otherwise indicated) were determined on cores. 7.5YR 3/4, color notation is interpreted as "five (7.5YR) valve (3), and chroma (4)", and identified as "dark brown" (color name). The full range of color notations and names are found in Munsell color books.

Texture: Refers to the soil particle size. Sicl, is interpreted as silty clay loam texture. The full range of notations is:

gravel..................g	gravelly sand loam....gsl
very coarse sand........vcos	loam..................l
coarse sand.............cos	gravelly loam.........gl
sand....................s	stony loam............stl
fine sand...............fs	silt..................si
very fine sand..........vfs	silt loam.............sil
loamy coarse sand.......lcos	clay loam.............cl
loamy sand..............ls	silty clay loam.......sicl
loamy fine sand.........lfs	sandy clay loam.......scl
sandy loam..............sl	stony clay loam.......stcl
fine sandy loam.........fsl	silty clay............sic
very fine sandy loam....vfsl	clay..................c

Structure: Refers to the way soil particles aggregate into peds. Structure notation describes the grade, size and form of the aggregates (peds). 2, c, abk is interpreted as "moderate, coarse, angular blocky structure." The range of notations is:

Grade	Size	Form
structureless....0	very fine......vc	platy.............pl
weak.............1	fine...........f	prismatic.........pr
moderate.........2	medium.........m	columnar..........cpr
strong...........3	coarse.........c	blocky............bk
	very coarse....vc	angular blocky....abk
		subangular blocky.sbk
		granular..........gr
		crumb.............cr
		(single grain.....sg)
		(massive...........m)

Consistence: Refers to the way soil behaves under finger pressure. The notation varies with moisture (wet, moist or dry soil), but in this study only moist soil consistence was determined. Mfr, is interpreted as "friable." The range of notations is:

loose..........ml	firm.............mfi
very friable....mvfr	very firm.........mvfi
friable.........mfr	extremely firm....mefi

Boundary Conditions: Refers to the distinctness and topography of the boundaries between soil horizons. a, s is interepeted as "abrupt smooth boundary." The range of notations is:

Distinctness:

abrupt (<2.5 cm thick)....a
clear (2.5-6 cm thick)....c
gradual (6-13 cm thick)...g
diffuse (>13 cm thick)....d

Topography:

smooth (nearly a plane)..................s
wavy (pockets with width > depth).........w
irregular (pockets with depth > width)....i
broken (discontinuous)...................b

Mottling: refers to the colors and pattern of soil mottles. Colors of mottles are noted by Munsell notations; pattern is noted in terms of their abundance, size, and contrast. c, 2, d, 7.5YR 3/4 is interpreted as "common, medium, distinct dark brown mottles." The range of notations is:

Abundance:

few (< 2% of surface)........f
common (2-20% of surface)...c
many (>20% of surface)......m

Size:

fine (<5 mm).........1
medium (5-15 mm).....2
coarse (>15 mm)......3

Contrast

faint (hue and chroma of matrix and mottles closely related).........................f

distinct (matrix and mottles vary 1-2 hues & several units in chroma and value).....d

prominent (matrix and mottles vary several units in hue, value, and chroma)......p

MLT 1 Described on 1/18/78 Location: T51N, R24W, Sec. 24, NE160, NW40, SE10, LaFayette Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
12	10YR 2/3	Si	0/1, c, pl
30	10YR 2/3	Si	1, c, sbk
50	10YR 2/3	Si	2, m/c, sbk
68	10YR 2/3	Si	½, c, sbk
85	7.5YR 2/3	Si	2, c, sbk
95	7.5YR 3/3	Si	2, c, sbk
110	7.5YR 4/4	Si	0/1, m/c, sbk
150	7.5YR 4/4	Si	2, c, abk
200	7.5YR 4/4	Si	2, c, sbk
225	7.5YR 4/4	Si	2, c, sbk
250	7.5YR 4/4	Si	2, c, abk
300	7.5YR 4/4	Si	2, c/vc, abk/sbk
350	7.5YR 4/3	Si	2, c, abk/sbk
400	7.5YR 4/4 10YR 4/4	Si	o, m
450	10YR 5/3	Si	o, m
500	10YR 5/3	Si	o, m
565	7.5YR 4/6	Si	o, m
585	10YR 4/3	Si	o, m

Comments

abk and sbk structure from 18 cm down is probably o, m; it is easy to 'make' peds out of loess, especially with angular faces; where structure is noted above, however, the peds 'made' were quite sturdy; few, medium (1 mm) roots to 110 cm; few fine roots to 200 cm; no pebbles,concretions, or reaction with Hcl; numerous root channelways (1 mm) dia.), most lacking distinct illuvial coatings; soil structural units are evident only when soil is dry or slightly damp, if moist, smaller silt aggregates readily fall out into fine, crumb structure to individual silt grains.

Locality . MLT 1 . . . . Date . 1/18/78 . . . . . .

Thickness of core cm (ft.). 0-180 (0-4) . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-18	A_p		10YR 2/3	Si	0/1,c, pl	mfr	a,s	
18-38	A_1		10YR 2/3	Si	1,c, sbk	mfr	c,w	
38-69	B_1		10YR 2/3	Si	2,m/c, sbk	mfr	c,w	
69-90	$B_{22t(?)}$		7.5YR 2/3	Si	2,c, sbk	mfr	c,w	
90-100	B_{23}		7.5YR 3/3	Si	2,c, sbk	mfr	c,w	
100-125	B_3		7.5YR 4/4	Si	0/1, m/c, sbk	mfr		7.5YR 6/6 Matrix (dry) f,1,d 7.5YR 2/1 along channelways. More often nothing on channelways.
125-180	C	-	7.5YR 4/4	Si	2,c, abk	mfr	g,i	

Locality . MLT 1 . . . . Date [illegible]/18/78 . . . .

Thickness of core cm (ft.). 160-575 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
180-265	C		7.5YR 4/4	Si	2,c, abk/sbk	mfr	c,w	
265-340			7.5YR 4/4	Si	2,c/vc abk/sbk	mfr	g,w	10YR 6/4 Matrix 10YR 6/2 c,2,f to m,3,f 7.5YR 3/4 f,1,d (rub off easily)
340-370			7.5YR 4/3	Si	2,c, abk/sbk	mfr	d,i	7.5YR 6/4 Matrix 10YR 6/2 m,3,f 7.5YR 3/4 c,1,d (rub off easily)
370-425			7.5YR 4/4 10YR	Si	o,m	mfr	c,w	7.5YR 5/6 Matrix 10YR 6/2 c,2,d 7.5YR 2,3 f,1,d
425-550			10YR 5/3	Si	o,m	mfr	c,w	10YR 5/3 Matrix 5YR 4/8 c,3,d 7.5YR 5/8
550-575			7.5YR 4/6	Si	o,m	mfr	c,w	7.5YR 5/8 - 50% 5YR 10YR 5/2 - 50%
575-590 Bottom			10YR 4/3	Si	o,m	mfr		10YR 5/3 Matrix 7.5YR 2/3-one stain found along a channel-way 7.5YR 5/8 f,2,f-very few very faint, very thin

MLT 2 Described on 10/26/77, 12/11/77, and 12/12/77 Location: T50N, R23W, Sec. 8, SW 160, NW40, SW10, Saline Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
10	10YR 3/2	Sil	1,m,pl
22.5	10YR 3/2	Sil	2,vf, sbk
30	10YR 3/2	Sil	2,f/m, sbk
40	10YR 3/2	Sil	2,f/m, sbk
50	7.5YR 2/2	Sil	2,f/m, sbk
60	7.5YR 3/2	Sil	1/2 f, sbk
70	7.5YR 3/3	Sil	2,f,sbk
80	7.5YR 3/2	Sil	2, vf, sbk
92.5	7.5YR 3/4	Sil	2, f, sbk
100	7.5YR 3/4	Sil	2, f/m, sbk
110	7.5YR 4/4	Sil	2, f/m, sbk
120			
125	10YR 4/4	Sil	
135	10YR 4/4	Sil	
145	10YR 4/4	Sil	
155	10YR 4/4	Sil	
165	10YR 4/4	Sil	
175	10YR 4/4	Sil	
185	10YR 4/4	Sil	
195	10YR 4/4	Sil	
205	10YR 4/4	Sil	
215	10YR 4/4	Sil	
225	10YR 4/4	Sil	

Comments

Biological channelways become larger and more numerous with depth after 70 cm; roots-present to 150 cm (tree roots?); somewhat gleyed between 125-225 cm, with layering of iron-stained mottles; all soil parent material appears to be silt; layers distinguished by mottling & changes in weak structure; no reaction throughout; dark mottles are concentrations of iron and manganese, light mottles are stains along biologic channelways; moderately gleyed below 225 cm; at 392-402 cm there occurs an increase in iron stains, plus a black Mn concentration 2 mm wide along a channelway at 390-395 cm; at 402 cm and down, matrix 'darkens' and takes on a greenish tint; Core ends at 432 cm.

. .6/77,
Locality MLT 2 . . . . Date 12/11/77, & 12/12/77

Thickness of core cm (ft.). 0-155 (4-8) . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-17	A_1	Many, fine grass roots	10YR 3/2	Sil	1 mpl	mfr	a,s	None
17-75	A_1	Roots end at 70 cm. Small bio-channelways	10YR 3/2 to 7.5 YR 3/3	Sil	2 f/m, sbk	mfr	a,s	None
75-90	A_2		7.5YR 3/2	Sil	1 vf, sbk	mfr	c,w	None
90-105	B_{1t}	Black, illuvial surfaces	7.5YR 3/4	Sil	2 f/m, sbk	mfr	c,w	None
105-117	B_{2t}	Bio-channelways are bigger	7.5YR 4/4	Sil	2 f/m, sbk	mfr		None
117-130	B_{22t}	Few, medium roots	10YR 4/4	Sil	2 m, sbk	mfr	c,w	None
130-155	B_{23}	Few, medium roots	10YR 4/4	Sil	2 m sbk	mfr	c,w	c,2,d 10YR 6/1 b, 1 iron stains same if clay

Locality MLT 2 Date 10/26/77, 12/11/77, & 12/12/77

Thickness of core cm (ft.). 155-312 (4-8)

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
155-175	B_3	Roots end @165	10YR 4/4	Sil	2 m sbk	mfr		m,2,d, gray c,1 iron stains
175-205	C_1		10YR 4/4	Sil	1,c, pl	mfr	g,w	m,3,d gray, f,1,d iron accumulations
205-237.5	C_2		10YR 4/4	Sil	2,vc, pl	mfr	g,w	50% gray 50% matrix of above (10YR 5/4) c,1 iron ac. 7.5YR 3/2
237.5-252			10YR 4/3	Sil	1 c,pl	mfr		50% Matrix 10YR 5/1 50% Iron Stain 10YR 4/4 f, 1, d 10YR 2/1
252-267			7.5YR 4/4	Sil	1 vc, pl	mfr		>50% Iron stain 7.5YR 4/6 almost no 10YR 2/1 mottles same 10YR 5/1 gleyed matrix
267-290			10YR 5/3	Sil	1 vc pl	mfr		c,2,d mottles 5YR 5/8 clearly along channelway 10YR 5/1 matrix f, 2, d 10YR 2/1, increasing w/depth
290-312			7.5YR 3/4	Sil	1,m,pl	mfr	a,s	m,3,d 7.5YR 2/2 on ped faces, channelways m,3, d 5YR 4/6 these 2 blend in places, increase with depth until abrupt stop at 312 cm, matrix same.

10/26/77

12/11/77 &12/12/77

Locality . . MLT 2 . . . . Date . . . .

Thickness of core cm (ft.) 312-432 (4-8) . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
312-357			10YR 5/3	Sil	o,m	mfr		10YR 5/1 matrix dark mottles absent c,m,d 5YR 4/6 stains & around channelways
237.5-392			10YR 4/4	Sil	o,m	mfr		Matrix 10YR 5/2 c, 1/2,d 5YR 5/8 (unrubbed mottles)
392-402			10YR 4/4	Sil	o,m	mfr		Matrix 10YR 5/2 m, 1/2,d 5YR 5/8 (unrubbed mottles)
402-432			10YR 5/4	Sil	o,m	mfr		Matrix 10YR 4/4 c, 1/2,d 5YR 5/8 (less distinct than above) (unrubbed mottles)

MLT 3 Described on 1/15/78 Location: T49N, R23W, Sec. 4, NE160, SW40, NE10, Saline Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
10	10YR 2/2	Si-sil	0/1, m, pl
21	10YR 2/2	Si-sil	0/1, m, sbk
	10YR 4/2		
40	10YR 2/2	Sil	1, m, sbk
	10YR 4/2		
70	10YR 2/3	heavy sil	1, m, pr
	10YR 3/3d		
100	10YR 4/3	heavy sil	o,m
	10YR 4/3d		
142	10YR 4/3	sil	o, m
172	10YR 4/4	sil	o, m
207	7.5YR 3/3	si-sil	o,m
230	7.5YR 4/4	si-sil	o,m
252	10YR 4/4	si-sil	o,m
300	10YR 4/3	si-sil	o,m

Comments

Few fine roots to 130 cm depth; gravels lacking throughout; no reaction with dilute Hcl throughout

Locality MLT 3 . . . . Date 1/15/78 . . . .

Thickness of core cm (ft.). 0-224 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-15	A_p		10YR 2/2	sil	0/1,m, pl	mfr	a,s	
15-25	A_{11}		10YR 2/2	sil	0/1,m, sbk	mfr	a,s	
25-60	A_{12}		10YR 2/2	sil	1,m,sbk	mfr	g,w	
60-77	B_{2t}		10YR 2/3	sil	1,m,pr	mfr	g,w	
77-163	B_3		10YR 4/3	sil	o,m	mfr	g,w	5YR 5/8 10YR 6/6 7.5YR 5/8 f,m,d 10YR 3/2 f,1,f (More at 140-150) 10YR 1.7/1 f,1,d
163-192	C_1		10YR 4/4	sil	o,m	mfr	c,w	matrix 10YR 6/2 5YR 4/8 f,1,p 7.5YR 5/8 c,2,d
192-224			7.5YR 3/3	sil	o,m	mfr	a,w	Matrix 10YR 6/1 40% 7.5YR 1.7/1 35% 7.5YR 5/8 25%

685

Locality MLT 3 Date 1/15/78

Thickness of core cm (ft.) 224-307

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
224-235			7.5YR 4/4	sil	o,m	mfr		'Matrix' 10YR 6/2 5YR 5/8 50-80% Iron stains to 235
235-263			10YR 4/4	sil	o,m	mfr	g,w	Matrix 10YR 6/2 c,2,d 5YR 5/8 15% mottled where they are along channelways w/small amounts of blackish stains also
263-307 Bottom			10YR 4/3	sil	o,m	mfr		Matrix 10YR 5/2 5 YR 5/8 c,2,d (along channelways)

MLT 4 Described on 1/20/78 Location: T48N, R23W, Sec. 5, SW160, SE40, SW10, Saline Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
15	10YR 2/2	sil	0/1, c, pl
30	10YR 2/2	sil	1, vf, sbk
50	10YR 2/3	sil	1, m, sbk
75	10YR 4/3	sil	0/1, c, sbk
105	10YR 4/4	sil	0/1, c, sbk or o,m
150	10YR 4/4	sil	o,m
200	10YR 4/4	sil	o,m
235	10YR 4/4	sil	o,m
250	10YR 4/4	sil	o,m
300	10YR 4/4	sil	o,m
350	10YR 5/1	sil	o,m
400	10YR 4/3	sil	o,m
450	10YR 5/4	sil	o,m
500	10YR 4/3	sil	o,m
550	10YR 5/4	sil	o,m
600	10YR 5/4	sil	o,m

Comments

Two large roots (5 mm) to 140 cm; few, fine roots to 240 cm; no gravels, or reaction to Hcl throughout.

Locality MLT 4 . . . . 687 . . . . Date 1/20/78 . . . .

Thickness of core cm (ft.). 0-230 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-20	A		10YR 2/2	sil	0/1,c, pl	mfr	a,s	
20-38	B_1		10YR 2/2	sil	1,vf, sbk	mfr	c,w	
38-60	B_{2t}		10YR 2/3	sil	1,m, sbk	mfr	c,w	
60-85	B_3		10YR 4/3	sil	0/1,c, sbk	mfr	g,w	10YR 3/2 m,2,f (≃50%) 10YR 5/3 Matrix
85-135	C_1		10YR 4/4	sil	0/1,c, sbk or o,m	mfr	g,w	10YR 2/2 f,1,d 7.5YR 5/4 m,3,f 10YR 5/3 matrix
135-162	C_2		10YR 4/4	sil	o,m	mfr	c,w	7.5YR 2/2 c,2,d 10YR 5/3 matrix 7.5YR 5/8 c,3,d
162-230		-	10YR 4/4	sil	o,m	mfr	c,w	Pockets 15 mm in diamete 7.5YR around 10YR 3/2 7.5YR 5/8 c,1/2,d Matrix 10YR 6/2

Locality MLT 4 Date 1/20/78

Thickness of core cm (ft.) 230-600

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
230-278			10YR 4/4	sil	o,m	mfr	g,w	10YR 7/1 5YR 4/8 vf, 1, p 7.5YR 6/6 m,3,d
278-346			10YR 4/4	sil	o,m	mfr	d,c	10YR 4/1 Matrix 5YR 5/8 2,m,d 7.5YR 2/1 2,m,d (concen- trated 300-315)
346-368			10YR 4/4	sil	o,m	mfr	c,w	10YR 7/1 50/50% 10YR 5/1
368-510			10YR 4/3 10YR 5/4	sil	o,m	mfr	g,w	10YR 5/1 Matrix 7.5YR 2/1 368-420 c,3,d 420-430 m,3,d (> 50%) 430- f,2,d
								7.5YR 5/8 clm,3,d
510-600 Bottom			10YR 5/4	sil	o,m	mfr		10YR 6/6 10YR 6/1 50/50 10YR 2,2, f,1,d

MLT 5 Described on 1/17/78 Location: T47N, R23W, Sec. 28, NW160, SW40, SE10, Pettis Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
12	10YR 2/3	si	0/1,c,pl
30	10YR 2/3	sil	3,c,cr
45	7.5YR 3/3	heavy sil	2,c,sbk
70	10YR 4/3	sil	o,m
100	10YR 4/3	sil	o,m
135	10YR 4/4	sil	o,m
150	10YR 6/1	sil	o,m
170	10YR 4/3	sil	o,m
205	10YR 4/4	sil	o,m
233	7.5YR 4/4	sil	o,m

Locality MLT 5 . . . . Date . 1/17/81 . . .

Thickness of core cm (ft.). 0-178 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-28	A		10YR 2/3	si	0/1,c, pl	mfr	a,s	
28-33	B_1		10YR 2/3	sil	3,c,cr	mfr	a,s	
33-58	B_{2t}		7.5YR 3/3	sil	2,c,sbk	mfi	c,w	
58-83	B_{3t}		10YR 4/3	sil	0,m	mfi	g,w	7.5YR 4/6 20-70% m,3,d 10YR 6/1-5/1 - Matrix
83-145	C_1		10YR 4/3 to 10YR 4/4	sil	0,m	mfi	c,w	7.5YR 1.7/1 f,1,d 7.5YR 6/8 c,2,d 5YR 5/8 f,1,d 10YR 7/1 Matrix
								137-139 cm 10YR 1.7/1 layer
145-157			10YR 6/1	sil	0,m	mfi	c,w	10YR 7/1 dry no mottling
157-178			10YR 4/3	sil	0,m	mfi	g,w	c,2,d 7.5YR 5/8 matrix 10YR 5/2

Locality . MLT 5 . . . . Date . 1/17/81 . . . .

Thickness of core cm (ft.). 178-237.5 . . . . .

Depth	178-222	222-237.5					
Horizon							
Comments							
Color (rubbed, or blended)	10YR 4/4	7.5YR 4/4					
Texture	sil	sil					
Structure	o,m	o,m					
Consistence	mfr	mfr					
Boundary Conditions	a,w						
Mottles	c,1,d 2.5YR 4/8 matrix 10YR 5/2	10% 2.5YR 4/8 10% 5YR 4/8 80% 5YR 5/8 c,1,p 7.5YR 1.7/1					

MLT 6 Described on 1/21/78 located: T45N, R23W, Sec. 23, NE 160, NW40, NE10 Pettis Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
15	10YR 3/2	sil	1,c,pl
25	10YR 3/3	sil	2,m,pl
38	10YR 3/3	sil	1,c,abk
68	10YR 4/3	sicl	2,c,sbk
100	10YR 5/3	sil	0/1,c,sbk
150	10YR 5/4	sil	1,c,pl
200	10YR 5/4	sil	0,m
300	10YR 5/4	sil	o,m
340	10YR 3/2	sil w/pebbles	o,m
370	loYR 5/2	sil	o,m
400	10YR 5/4	sil	o,m

Comments

Few fine roots to 75 cm; black mottles increase, and hardened concretions occur between 200-300 cm; a few pebbles (up to 3 mm dia.) below 270 cm.

Locality . . MLT 6 . . . . Date . . 1/21/78 . .

Thickness of core cm (ft.). . 0-308 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-20	$A_{p?}$		10YR 3/2	sil	1,c,pl	mfr	a,s	
20-28	A_1		10YR 3/2	sil	2,m,pl	mfr	c,w	
28-46	B_1		10YR 3/3	sil	1,c,abk	mfr	g,w	
46-80	B_{2t}		10YR 4/3	sicl	2,c,sbk	mfr	g,w	
80-136	B_3		10YR 5/3	sil	0/1,c, sbk	mfr	g,w	7.5YR 2/1 f,2,d 10YR 5/6 60% Matrix 10YR 6/1 40%
136-188	C_1		10YR 5/4	sil	1,c,pl	mfr	g,w	7.5YR 2/1 f,2,d 7.5YR 4/6 c,2,d (around 7.5YR 5/8 Matrix black 10YR 6/1 ones)
188-308			10YR 5/4	sil	o,m	mfr	a,w	7.5YR 2/1 c,2,d (many from 188-200) 7.5YR 4/6 same as above 7.5YR 5/8 Matrix 10YR 5/1 10YR 7/1 - large inclusory from 240-260 50% matrix

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Locality . . . MLT 6 . . . Date . . . 1/21/78

Thickness of core cm (ft.). . . 308-407 . . .

Depth	308-352	352-387	387-407 bottom				
Horizon							
Comments							
Color (rubbed, or blended)	10YR 3/2	10YR 5/2	10YR 5/4				
Texture	sil	sil	sil				
Structure	o,m	o,m	o,m				
Consistence	mfr	mfr	mfr				
Boundary Conditions	a,w	a,w					
Mottles	10YR 2/2 7.5YR 5/8 Matrix 50/50 very striking	7.5YR 6/8 matrix 50/50 7.5YR 6/2 m,1,d 10YR 2/2	7.5YR 6/8-Much brighter than 352-387 7.5YR 6/2 m,2,d 10YR 2/2				

MLT 7 Described on 1/14/78 Location: T44N, R22W, Sec. 32, SW160, SE40, SE10, Pettis Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
12	10YR 2/3 (10YR 5/3d)	sil	1,c,pl
28	10YR 2/3 (7.5YR 2/2d)	sil	1,m/c, sbk
50	10YR 3/3 (7.5YR 2/2d)	sil	o,m
76	10YR 3/3 (7.5YR 4/2d)	si-sil	0/1,c,sbk
100	10YR 5/4 (10YR 5/2d)	si-sil	0/1,m,pr
130	10YR 5/4	sil	0/1,m,pr
190	10YR 5/6	sil	o,m
250	10YR 5/4	sil	o,m

Comments

Common, medium roots to 70 cm (1 mm dia.), few, fine roots to bottom (120 cm); very few, fine roots to 130 cm; no reaction to dilute Hcl; no gravels down to 170 cm, but very large pebbles from 180 downward (up to 5 cm in diameter, angular dolomite, with a concentration between 180-200 cm).

Locality . . . MLT 7 . . . Date . . . 1/14/78

Thickness of core cm (ft.). . . 0-217

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-23	A		10YR 2/3	sil	1,c,pl	mfr	a,s	
23-33	B_1		10YR 2/3	sil	1,m/c, sbk	mfr	c,w	
33-67	B_{2t}		10YR 3/3	sil	o,m	mfi	c,w	
67-83	B_{3t}		10YR 3/3	sil	0/1,c, sbk	mfr	c,w	10YR 5/8 75YR 5/8 c,2,d (don't look distinct)
83-120	C_1		10YR 5/4	sil	0/1,m, pr	mfr		10YR 5/8 7.5YR 5/8 m,c,d
120-156	C_1		10YR 5/4	sil	0/1,m, pr	mfi	g,w	10YR 6/2 matrix 75YR m,3,d (Iron)
146-217	C_2	-	10YR 5/6	sil	o,m	mfi	c,w	10YR 5/1 Matrix 7.5YR 5/6 m,3,d (iron) 10YR 2/1 around channel ways, mostly from 190-217 cm f/c,c,p

Locality . MLT 7 . . . . Date . 1/14/78 . . . . .

Thickness of core cm (ft.). 217-258 . . . . . .

Depth	217-258 Bottom
Horizon	C_3
Comments	
Color (rubbed, or blended)	10YR 5/4
Texture	sil
Structure	o,m
Consistence	mfi
Boundary Conditions	
Mottles	10YR 6/8 m,3,d (iron stain) 10YR 7/1 matrix

MLT 8 Described on 1/15/78 Location: T42N, R22W, Sec. 9, SE160, SE40, SE10 Benton Co. MO.

General Description

Depth (cm)	Color	Texture	Structure
10	10YR 2/3 (10YR 5/2 dry)	si-sil	1,m,pl
30	10YR 2/3 (10YR 2/1 dry)	si-sil	0/1,c,sbk
60	10YR 2/3 (10YR 2/1 dry)	heavy sil	2,c,sbk
105	10YR 4/4	si-sil	o,m
140	10YR 5/4	si-sil	o,m
175	10YR 5/4	si-sil	o,m
187	10YR 5/3	si-sil	o,m
222	10YR 5/4	heavy sil	o,m
270	10YR 5/4	heavy sil	o,m

Comments

Many fine roots to 45 cm; few, fine roots and hereafter; no pebbles to 120 cm.

Locality . MLT 8 . . . . Date . 1/15/78 . . . .

Thickness of core cm (ft.). . . 0-350 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-19	A_p		10YR 2/3	sil	1,m,pl	mfr	a,s	
19-40	A_{11}		10YR 2/3	sil	0/1, c, sbk	mfr	g,w	
40-77	A_{12}		10YR 2/3	sil	2,c,sbk	mfr	c,w	
77-152	B_{2t}		10YR 4/4 and 10YR 5/4	sil	o,m	mfr	c,w	Matrix 10YR 5/2 m,3,d 7.5YR 6/8
152-194	B_3	Iron stains seem to be concen- trated in certain areas.	10YR 5/4 and 10YR 5/3	sil	o,m	mfr	d,i	Matrix 10YR 7/2 m,3,d 7.5YR 5/8
194-340	C_1	Matrix darkens small, few chert pebbles at 220-340 (<15 mm), black, illuvial surfaces along channelways, f,l,d except 335-340 where c,l,fld	10YR 5/4 to 10YR 5/6	sil	o,m	mfr	c,w	10YR 6/1 f,m,d 7.5YR 5/8 m,3,d 7.5YR 4/6 10YR 8/2 dusty covering in certain regions
340-350	C_2	>50% pebbles up to 8 cm.						(pebble disintegration)

MLT 9 Described on 12/18 Location: T41N, R22W, Sec. 16, NW160, NW40, NW10, Benton Co, MO.

General Description

Depth (cm)	Color	Texture	Structure
NOT	AVAILABLE		

Comments

Common, fine roots throughout profile; iron, manganese, and illuvial clay below 35 cm; 60-65 cm (bottom) - many v. fine chert pebbles (<5 mm dia.), with abundant clay and iron oxides; no reaction throughout; coarse pebbles (20-50 mm) at 45 and 50 cm; core ends at 65 cm in pebbly material.

Locality MLT 9 Date 12/18

Thickness of core cm (ft.) 0-65

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-13	A_p		10YR 5/2d 10YR 2/2	sil	2 mpl	ds mfr	a,s	
13-20	A_1		10YR 4/3d 10YR 2/3	sil	1,f, sbk	mfr	a,s	
20-35	A_2		10YR 6/2d 10YR 4/2	sil	2m sbk	mfr	a,s	
35-55	B_{2t}		10YR 5/3d 10YR 4/3	sil	2,f sbk	mfr	cs	
55-60	B_{3t}	Ped interiors: 10YR 8/4d Ped coatings: 5YR 5/6 10YR 1.7/1	10YR 5/4	sil	2,f sbk	mfr	as	m2p
60-65	C_1	Mottles mostly - 10YR 2/1 5YR 5/8 10YR 7/6 very pebbly in this layer	10YR 4/4	sil	1,v,f-m sbk	mfr		m3p

MLT 10 Described on 12/18 Location: T41N, R22W, Sec. 16, NE160, NE40, NE10, Benton Co., MO.

General Description

(not available)

Comments

Fine and medium pebbles throughout profile (less than 1%); thick grass roots in A_p & A_1 with common, fine roots through the rest.

Locality MLT 10 703 Date 12/18

Thickness of core cm (ft.) 0-60

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-13	A_p		10YR 5/2d 10YR 2/3m	-	1,f,pl	mfr	a,s	
13-20	A_1		10YR 6/2d 10YR 3/3m	-	2 f sbk	-	a,s	
20-31	B_{21t}	Common dark illuvial channels: 10YR 2/1d	7.5YR 3/3d 10YR 3/3m	-	3,m sbk	-	c,s	
31-45	B_{22t}	peds rather dark	10YR 3/3d 10YR 4/3m	-	3 m/c sbk	-	c,s	
45-58	B_{3t}	Illuvial zones: 10YR 2/2d c,2,d	10YR 5/6d 10YR 6/1d 10YR 4/3m	-	3 m sbk	-	c,s	
58-60	C_1	Dry colors not very strikingly different over a large range. Equal parts of each.	10YR 5/6d 10YR 7/1d 10YR 2/2d 10YR 4/3m	-	3 m sbk	-		

MLT 11 Homestead Hill Described on 1/12/78 Location: T39N, R22W, Sec. 34, SW160, SW40, NW10, Benton Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
12	10YR 4/3	si	0/1,m,pl
30	10YR 5/4	sil	2,m,sbk
45	10YR 5/4	sil	2,m,sbk
62	7.5YR 4/6	sil	3,m,sbk
100	5 YR 4/8	sil	0/1,m,sbk
120	5YR 4/8	sil very silty	o,m
135	7.5YR 4/6	sil	o,m

Comments

Peds not as durable at 45 cm as at 30 cm, and are more evident in place; few fine roots to 120 cm; channelways throughout profile;

Locality . . MLT 12 (Homestead Hill) . . . . Date . 1/12/78 . . .

Thickness of core cm (ft.). 0-140 . . . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-21	A_1		10YR 4/3	si	0/1,m, pl	mfr	a,s	
21-40	A_2		10YR 5/4	sil	s,m, sbk	mfr	a,s	
40-49	B_1		10YR 5/4	sil	2,m, sbk	mfr	a,w	
49-84	B_{21t}		7.5YR 4/6	sil	3,m, sbk	mfr	g,w	50% 7.5YR 3/3 c,1,f 5YR 4/6
84-110	B_{22t}		5YR 4/8	sil	0/1,m, sbk	mfr	g,w	50%-80% 2.5YR 3/6 2.5YR 4/8 c,2,d 7.5YR 3/3 c,2,d 7.5YR 7/2
110-130	B_{3t}		5YR 4/8	sil	0,m	mfr	c,w	80% 2.5YR 4/6 2.5YR 4/8 c,2,d 10YR 6/3
130-140	C_1		7.5YR 4/6	sil	0,m	mfr		c,2, 5YR 5/8 Matrix 7.5YR 6/4

MLT 12 Described on 1/10/78 Location: T37N, R22W, Sec. 7, SW160, NE40, NE10, Hickory Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
7.5	10YR 3/3	si	1,c,pl
20	10YR 3/3	si	1,c,pl
30	7.5YR 4/3	sil	2,f-m/cr
47.5	7.5YR 4/3	sil	2,m,sbk
60	7.5YR 4/3	sil	2,c,sbk
75	10YR 5/2	sil	3,c,sbk
90	10YR 5/4	sil	2,f-m,sbk
110	10YR 5/6	sil	2,f-m,sbk
140	10YR 5/6	sil	2,f-m,sbk
155	2.5YR 6/2	si	1,f-m,sbk
180	10YR 6/6	sil	1,f-m,sbk

Comments

Below 85 cm biologic channelways are lined with small amounts of organic matter; intact root found at 165 cm; below 100 cm-iron staining is consistent, change is in matrix color and, maybe, texture; possibly the parent material changes; chert pebbles begin at 195 cm.

Locality . . . MLT 12 . . . Date . 1/10/78 . . .

Thickness of core cm (ft.). 0-100 . . . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Unrubbed Mottles
0-12.5	A_p		10YR 3/3	si	1,c,pl	mfr	A,s	
12.5-23.0	A_1	Structure better defined than A_p	10YR 3/3	si	1,c,pl	mfr	a,s	
23-45	B_1		7.5YR 4/3	sil	2,f-m, cr	mfr	c,s	c,1,b 7.5YR 4/8
45-54	B_{21}	Iron stains probably masked by clay	7.5YR 4/3	sil or sicl	2,m, sbk	mfr	c,w	
54-66	B_{22}		7.5YR 4/3	sicl	2,c, sbk	mfi	c,w	
66-82	B/C	10YR 4/2d inclusions are like B_{22}, 10YR 6/2 like C_1	10YR 5/2	sil	3,c,sbk	mfi	c,w	Matrix 10YR 6/2 and 10YR 4/2 f,1,f 7.5 YR 4/6
82-100	C_1 IIC_1?	IIA_2? very light colored matrix	10YR 5/4	sil	2,f-m, sbk	mfr	a,s	Matrix 10YR 8/1 30% 10YR 4/2 f,1,d 7.5YR 6/8

Locality MLT 12 708 Date 1/10/78

Thickness of core cm (ft.) 100-185

Depth	100-195	155-165	175-185
Horizon	C_{22} IIC_{20}		
Comments	same light colored matrix w/more iron stains		large inclusion of matrix of 10YR 5/1d w/same stains
Color (rubbed, or blended)	10YR 5/6 to 10YR 6/6	2.5YR 6/2	
Texture	sil	si	
Structure	2,f-m, sbk to 1,f-m, sbk	1,f-m, sbk	
Consistence	mfr	mfr	
Boundary Conditions	a,s		
Mottles	Matrix 10YR 7/1 40-70% Iron stain 10YR 6/8		

MLT 13A Described on 1/12/78 Location: T37N, R23W, Sec. 25, SW, SW, SW, Hickory Co., MO.

General Description

Depth(cm)	Color	Texture	Structure
10	10YR 2/3	si-sil	0/1,c,pl
30	7.5YR 3/4	sil	2,vf-f,sbk
37	7.5YR 3/4	heavy sil	3,c,sbk
50	10YR 4/3	heavy sil	2,c,sbk
65	10YR 4/3	sil	1-2,m,sbk
75	10YR 4/3	sil	o,m

Comments

Few, fine roots throughout profile few obvious illuvial surfaces; in C_1. Few. very small (<5 mm) pebbles in C; very few larger (5-10 mm) pebbles throughout.

Locality . MLT 13A . . . . Date . 1/12/78 . . . .

Thickness of core cm (ft.). 0-75 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-24	A		10YR 2/3	si-sil	0/1,c, pl	mfr	a,s	
24-33	B_1	Common, very faint iron stains	7.5YR 3/4	sil	2,vf-f sbk	mfr	c,w	
33-40	B_{21}		7.5YR 3/4	heavy sil	3,c, sbk	mfr	c,w	
40-58	B_{22t}		10YR 4/3	heavy sil	2,c, sbk	mfr	c,w	
58-67.5	C_1	Matrix 50/50 10YR 4/2 10YR 7/1 (unrubbed) [c,1/2,d 5YR 5/8]	10YR 4/3	sil	1/2,m, sbk	mfr	a,w	
67.5-75	C_2	Matrix 10YR 7/1	10YR 4/3	sil	o,m	mfr		

MLT 13B Described on 1/12/78 Location: T37N, R23W, Sec. 25, SW160, SE40, SW10, Hickory Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
10	10YR 3/3	si-sil	0/1,c,pl
20	10YR 3/3	si-sil	1,c,pl
32	7.5YR 4/6	sil	3,vf,sbk
42.5	7.5YR 4/4	sil	1,m,sbk or 3,vf,sbk cemented together w/clay and organics
	10YR 5/4	sil	2,c,sbk

Comments

Few pebbles and few, fine roots throughout profile.

Locality . . . MLT 13B . . . . Date . . . 1/12/78 . . .

Thickness of core cm (ft.). . . 0-66 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-15	A_p		10YR 3/3	sil	0/1,c,pl	mfr	a,s	
15-27	A_1		10YR 3/3	sil	1,c,pl	mfr	a,s	
27-37	B_{1t}		7.5YR 4/6	sil	3,vf,sbk	mfr	c,w	
37-51	B_{2t}	unrubbed matrix: 10YR 6/3	7.5YR 4/4	sil	1,m,sbk	mfr	g,w	>50% 10YR 2/2 c,1,d 2.5 YR 4/6
51-66	C_{1t}	unrubbed matrix: 10YR 7/4 block skins are not revealed on initial breaking open of core, after applying more pressure, large peds(?) break to reveal up to 50% dark coatings on smaller peds	10YR 5/4	sil	2,c,sbk	mfr		

MLT 14A Described on 1/13/78 Location: T37N, R22W, Sec. 30, NW160, SE40, SE10, Hickory Co., MO.

General Description

Depth (cm)	Color	Texture	Structure
13	10YR 3/3	si	1,c,pl
25	7.5YR 4/4	sil	1,m,sbk
40	7.5YR 3/4	sil	o,m
55	7.5YR 4/3	sicl	o,m
70	10YR 4/4	sil	o,m
85	10YR 4/3	sil	o,m
110	10YR 5/4	sil	0/1,m,pr
150	10YR 5/4	sil	0/1,m,pr
210	10YR 5/2	sil	o,m
230	10YR 5/6	heavy sil	o,m
270	10YR 5/6	sicl	o,m

Comments

C_2/C_3 boundary is very abrupt with dark iron stains and heavier texture starting immediately; chert pebbles up to 3 cm in diameter occur in the C_3 (around 2% of volume).

Locality . . MLT 14A . . . . Date 1/13/78 . . . .

Thickness of core cm (ft.). 0-120 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
0-23	A_1		10YR 3/3	si	1,c,pl	mfr	c,s	
23-30	AB		7.5YR 4/4	sil	1,m, sbk	mfr	c,s	
30-50	B_{22t}		7.5YR 3/4	sil	o,m	mfi	g,w	
50-60	B_{23t}		7.5YR 4/3	sil	o,m	mfi	g,w	
60-79	B_{31}		10YR 4/4	sil	o,m	mfi	c,w	5YR 5/8 f,1,d 10YR 4/2 matrix 10YR 6/2 50/50
79-94	B_{32}		10YR 4/3	sil	o,m	mfi	c,w	5YR 5/8 c,2,d 10YR 2/2 50-75% matrix 10YR 6/2 (rest of matrix
94-120	C_1		10YR 5/4	sil	0/1, m,pr	mfr	c,w	7YR 6/8 to 5YR 5/8 c,2,d Matrix is 10YR 7/2 and few very prominent black stains along channelways

Locality . MLT 14A . . . . Date . 1/13/78 . . . .

Thickness of core cm (ft.). 120-310 . . . .

Depth	Horizon	Comments	Color (rubbed, or blended)	Texture	Structure	Consistence	Boundary Conditions	Mottles
120-185	C_1		10YR 5/4	sil	0/1,m, pr	mfr	d,w	Mottling slowly decreases in frequency until only gleying remains in zone below
185-223	C_2		10YR 5/2	sil	o,m	mfr	a,s	Gleyed zone very abrupt boundary to 10YR 5/2 unrubbed
223-310	C_3		10YR 5/6	heavier sil to sil	o,m	mfr		7.5YR 5/8 50% 5YR 5/8 10YR 5/2 · 50%

MLT 14B (Not described)

Appendix C

This appendix contains precipitation, dam discharge, well levels, soil profile descriptions, and soil laboratory data for the Avery Bridge transect study area.

Appendix C.
Precipitation, dam discharge, and well level at Avery Bridge, lower Pomme de Terre River, Missouri.

Date	Precip-ipitation*	Discharge*	Depth to the Free Water Surface			
			Well A	Well B	Well C	Well D
8-04-78	0.00	900.	311.	411.	448.	497.
8-05-78	0.00	100.	280.	396.	422.	490.
8-06-78	0.00	100.	262.	385.	405.	497.
8-07-78	0.00	100.	259.	382.	401.	495.
8-08-78	0.00	900.	250.	374.	392.	495.
8-09-78	0.00	900.	284.	368.	385.	497.
8-10-78	0.00	900.	264.	362.	377.	496.
8-11-78	.51	900.	257.	356.	370.	494.
8-12-78	2.79	900.	236.	249.	365.	492.
8-13-78		900.				
8-14-78	0.00	100.	236.	248.	355.	486.
8-15-78	.25	900.	236.	248.	352.	485.
8-16-78	0.00	900.	252.	248.	352.	482.
8-17-78	0.00	100.	253.	248.	347.	481.
8-18-78	0.00	900.	253.	247.	346.	479.
8-19-78	0.00	900.	256.	264.	345.	478.
8-20-78		900.				
8-21-78	0.00	900.	274.	268.	345.	475.
8-22-78	0.00	50.	279.	272.	345.	473.
8-23-78	0.00	50.	281.	274.	345.	473.
8-24-78	0.00	50.	280.	275.	344.	472.
8-25-78	.76	50.	280.	279.	344.	471.
8-26-78	0.00	50.	289.	279.	344.	470.
8-27-78		50.				
8-28-78	2.79	50.	288.	229.	346.	467.
8-29-78	0.00	50.	295.	239.	347.	464.
8-30-78		50.				
8-31-78	0.00	50.	306.	251.	348.	461.

*Precipitation and depth are in centimeters, discharge is cubic feet/second.

Appendix C.
Precipitation, dam discharge, and well level at Avery Bridge, lower Pomme de Terre River, Missouri.

Date	Precip-ipitation	Discharge	Depth to the Free Water Surface			
			Well A	Well B	Well C	Well D
9-01-78	0.00	50.	305.	256.	348.	460.
9-02-78	0.00	50.	305.	260.	353.	459.
9-03-78		50.				
9-04-78	.51	50.	313.	270.	352.	457.
9-05-78		50.				
9-06-78	0.00	50.	312.	269.	354.	454.
9-07-78	0.00	50.	320.	283.	357.	454.
9-08-78	0.00	50.	323.	287.	359.	454.
9-09-78	0.00	50.	323.	287.	360.	454.
9-10-78		50.				
9-11-78	0.00	50.	327.	297.	361.	452.
9-12-78	0.00	50.	326.	296.	367.	451.
9-13-78	0.00	50.	330.	299.	365.	450.
9-14-78	3.56	50.	315.	265.	365.	449.
9-15-78	.25	50.	315.	265.	365.	446.
9-16-78	0.00	50.	331.	276.	360.	446.
9-17-78		50.				
9-18-78	0.00	50.	335.	284.	371.	444.
9-19-78	0.00	50.	339.	287.	371.	444.
9-20-78		50.				
9-21-78	0.00	50.	339.	288.	372.	442.
9-22-78	.25	50.	345.	297.	372.	441.
9-23-78	0.00	50.	344.	297.	376.	441.
9-24-78		50.				
9-25-78	0.00	50.	347.	304.	378.	440.
9-26-78	0.00	50.	351.	304.	378.	439.
9-27-78	0.00	50.	352.	307.	379.	440.
9-28-78	0.00	50.	352.	308.	380.	440.
9-29-78	0.00	50.	353.	310.	352.	437.
9-30-78	1.02	50.	352.	309.	381.	438.

Appendix C.
Precipitation, dam discharge, and well level at Avery Bridge, lower Pomme de Terre River, Missouri.

Date	Precipitation	Discharge	Depth to the Free Water Surface Well A	Well B	Well C	Well D
10-01-78		50.				
10-02-78	0.00	50.	358.	316.	383.	437.
10-03-78	0.00	50.	358.	317.	385.	437.
10-04-78	0.00	50.	360.	320.	386.	437.
10-05-78	.51	50.	262.	319.	386.	437.
10-06-78	0.00	50.	263.	320.	386.	437.
10-07-78	0.00	50.	366.	323.	388.	438.
10-08-78		50.				
10-09-78	0.00	50.	362.	326.	390.	437.
10-10-78	.51	50.	361.	326.	391.	437.
10-11-78	1.52	50.	361.	326.	391.	437.
10-12-78	0.00	50.	362.	327.	392.	436.
10-13-78	1.52	50.	365.	329.	393.	436.
10-14-78	0.00	50.	366.	330.	393.	436.
10-15-78		50.				
10-16-78	0.00	50.	365.	330.	393.	435.
10-17-78	0.00	50.	366.	331.	395.	434.
10-18-78	0.00	50.	368.	332.	397.	435.
10-19-78	0.00	50.	369.	332.	397.	434.
10-20-78	0.00	50.	369.	333.	398.	434.
10-21-78		50.				
10-22-78	.25	50.	370.	334.	398.	434.
10-23-78	0.00	50.	374.	337.	400.	435.
10-24-78	0.00	50.	373.	337.	400.	434.
10-25-78	0.00	50.	373.	338.	400.	434.
10-26-78	0.00	50.	372.	339.	400.	434.
10-27-78	0.00	50.	375.	338.	402.	435.
10-28-78	0.00	50.	375.	338.	402.	435.
10-29-78		50.				
10-30-78	0.00	50.	374.	339.	402.	434.
10-31-78	0.00	50.	375.	340.	403.	434.

Appendix C.
Precipitation, dam discharge, and well level at Avery Bridge, lower Pomme de Terre River, Missouri.

Date	Precip-ipitation	Discharge	Depth to the Free Water Surface			
			Well A	Well B	Well C	Well D
11-01-78	0.00	50.	375.	342.	403.	434.
11-02-78	0.00	50.	378.	244.	406.	435.
11-03-78	0.00	50.	379.	347.	407.	436.
11-04-78	0.00	50.	381.	349.	408.	437.
11-05-78		50.				
11-06-78	1.27	50.	382.	351.	409.	437.
11-07-78	0.00	50.	382.	352.	410.	437.
11-08-78	0.00	50.	383.	353.	411.	438.
11-09-78	0.00	50.	383.	354.	411.	438.
11-10-78	0.00	50.	383.	355.	412.	438.
11-11-78	0.00	50.	384.	355.	412.	438.
11-12-78		50.				
11-13-78	3.05	50.	368.	353.	413.	437.
11-14-78	0.00	50.	371.	356.	414.	438.
11-15-78	2.03	50.	356.	352.	415.	437.
11-16-78	0.00	50.	334.	336.	414.	435.
11-17-78	0.00	50.	315.	319.	414.	432.
11-18-78	.25	50.	317.	320.	414.	433.
11-19-78		50.				
11-20-78	0.00	50.	333.	308.	410.	430.
11-21-78	0.00	50.	332.	308.	410.	430.
11-22-78	1.02	50.	327.	308.	406.	429.
11-23-78	0.00	50.	324.	308.	406.	429.
11-24-78	0.00	50.	325.	308.	405.	429.
11-25-78		50.				
11-26-78	8.64	50.	143.	116.	395.	283.
11-27-78	0.00	50.	152.	127.	386.	343.
11-28-78	0.00	50.	157.	151.	368.	348.
11-29-78	0.00	50.	177.	165.	361.	364.
11-30-78	0.00	50.				

Appendix C.
Profile descriptions and laboratory data

Avery Bridge Transect 89

Location:	Southern Benton County, Missouri, by Pomme de Terre river, west of former Avery Bridge
Geomorphic surface:	River terrace
Vegetation:	Recently cultivated, formerly probably deciduous forest
Relief:	0-1% slope
Collected by:	D. L. Johnson and C. Benkovich, August, 1977.
Described by:	D. W. Stegner, January, 1978.

Appendix C.
Description for profile no. 1

Core identification: 1
Soil type: Aquic Hapludalf

Depth	Horizon	Description
0-5	Ap	Dark brown (10 YR 3/3) silt loam; weak, medium platy; friable; no reaction with HCl; common fine roots, few medium roots; few chert fragments; abrupt smooth boundary to
5-26	A12	Dark brown (10 YR 3/3) silt loam; weak medium subangular blocky; friable; no reaction with HCl; common fine roots, few medium roots; few faint mottles; clear smooth boundary to
26-65	A2	Gray brown (10 YR 5/2) silt loam; very weak, medium subangular blocky; very friable; no reaction with HCl; few fine roots; common medium manganese concretions; common distinct mottles (7.5 YR 5/6); clear smooth boundary to
65-80	B1	Dark brown (10 YR 4/3) silt loam; weak, medium to coarse subangular blocky; friable; no reaction with HCl; few fine roots; common fine and medium manganese concretions; few faint mottles; common thin argillans (10 YR 4/2); clear smooth boundary to
80-158	B2t	Dark brown (10 YR 4/3) silty clay loam; weak, medium to coarse subangular blocky; firm; no reaction with HCl; common fine and medium manganese concretions; common distinct mottles (7.5 YR 5/6); common thin to moderately thick argillans (10 YR 3/1); gradual smooth boundary to
158-end	C	Dark brown (10 YR 4/3) silty clay loam; structureless; massive; firm; no reaction with HCl; common fine and medium manganese concretions; common distinct mottles (7.5 YR 5/6); common thin argillans (10 YR 3/1)

Appendix C.
Particle size data for profile no. 1

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
1	1201	0	18.21	4.25	77.54	1274	17.08	4.00	78.92
1	1202	10	17.75	3.74	78.51				
1	1203	20	17.44	4.05	78.51	1275	15.84	4.18	79.98
1	1204	30	17.09	3.89	79.02				
1	1205	40	17.64	4.17	78.19	1276	15.59	4.94	79.47
1	1206	50	17.88	4.38	77.74				
1	1207	60	17.06	4.69	78.25	1277	15.82	4.80	79.38
1	1208	70	23.05	3.85	73.10				
1	1278	80	24.53	4.42	71.05	1291	27.68	4.56	67.76
1	1292	90	28.66	3.92	67.42				
1	1279	100	28.58	4.47	66.95	1293	28.65	4.32	67.02
1	1294	110	29.72	3.41	66.87				
1	1281	120	31.94	4.53	63.53	1295	30.95	4.52	64.53
1	1296	130	33.39	2.47	64.13				
1	1282	140	32.30	2.52	65.18	1297	32.94	2.22	64.83
1	1298	150	31.09	2.48	66.43				
1	1299	160	29.74	2.55	67.71				
1	1211	170	28.94	2.80	68.26				
1	1212	180	28.19	3.14	68.68				
1	1213	190	27.84	1.93	70.23				
1	1214	200	27.90	2.34	69.76				
1	1215	210	28.17	2.18	69.65				
1	1216	220	28.36	2.52	69.12.				

Appendix C.
Description for profile no. 2

Core identification: 2
Soil type: Aquic Hapludalf

Depth	Horizon	Description
0-22	Ap	Dark brown (10 YR 3/3) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; common fine and medium roots; few chert fragments; abrupt smooth boundary to
22-54	A2	Very dark gray brown (10 YR 3/2) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; few fine roots; few fine manganese concretions; few faint mottles; few chert fragments; clear smooth boundary to
54-85	B1	Dark brown (10 YR 3/3) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; few fine roots; common faint mottles; few fine manganese concretions; few thin silans; gradual smooth boundary to
85-115	B2t	Dark brown (10 YR 4/3) silty clay loam; weak medium subangular blocky; very friable; no reaction withh HCl; few fine roots; few faint mottles; few fine manganese concretions; common thin to moderately thick argillans; gradual smooth boundary to
115-end	C	Dark brown (10 YR 4/3) silty clay loam; structureless massive; firm; no reaction with HCl; common faint mottles; common thin argillans.

Appendix C.
Particle size data for profile no. 2

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
2	1071	0	15.05	4.89	80.06	1102	16.66	4.94	78.40
2	1072	10	15.24	4.18	80.58				
2	1073	20	13.99	4.44	81.57	1103	16.31	4.71	78.97
2	1074	30	15.83	3.96	80.22				
2	1075	40	15.94	4.24	79.82	1104	18.36	4.59	77.05
2	1076	50	16.15	3.87	79.98				
2	1077	60	16.59	4.33	79.09	1105	19.20	4.66	76.15
2	1078	70	17.59	6.15	76.26				
2	1079	80	18.60	5.94	75.46	1106	20.60	5.33	74.07
2	1081	90	23.63	4.71	71.66				
2	1082	100	25.63	5.14	69.22	1107	26.58	5.12	68.30
2	1083	110	28.30	4.88	66.83				
2	1084	120	26.97	4.69	68.34	1108	28.05	4.79	67.15
2	1085	130	28.15	4.52	67.33				
2	1086	140	26.85	4.56	68.59	1109	28.97	4.30	66.73
2	1087	150	28.32	4.35	67.33				
2	1088	160	28.27	3.68	68.05				
2	1089	170	31.33	2.93	65.74				
2	1091	180	30.39	2.82	66.79				
2	1092	190	30.80	2.82	66.38				
2	1093	200	30.60	2.74	66.66				
2	1094	210	30.80	2.21	66.99				
2	1095	220	30.83	2.20	66.97				
2	1096	230	30.30	1.89	67.81				
2	1097	240	29.82	1.91	68.27				
2	1098	250	29.82	1.71	68.47				
2	1099	260	30.65	2.48	66.87				
2	1101	270	31.25	2.46	66.29				

Appendix C.
Description for profile no. 3

Core identification: 3
Soil type: Aquic Hapludalf

Depth	Horizon	Description
0-21	Ap	Dark brown (10 YR 3/3) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; few fine roots; abrupt smooth boundary to
21-38	A12	Dark brown (10 YR 3/3) silt loam; moderate, coarse platy; friable; no reaction with HCl; few fine roots; clear smooth boundary to
38-90	A3	Dark brown (10 YR 3/3) silt loam; very weak, coarse subangular blocky; friable to firm; no reaction with HCl; few fine roots; many fine manganese concretions; gradual smooth boundary to
90-115	B2t	Dark yellowish brown (10 YR 3/4) silty clay loam; moderate to strong, medium to coarse subangular blocky; firm; no reaction with HCl; few fine roots; few fine manganese concretions; few silans; few to common moderately thick argillans; few distinct mottles (7.5 YR 5/6); gradual smooth boundary to
115-end	C	Dark brown (10 YR 3/4) silt loam; weak, coarse subangular blocky to structureless massive; firm; few fine manganese concretions; few thin argillans; common silans; many coarse, distinct mottles (7.5 YR 5/4).

Appendix C.
Particle size data for profile no. 3

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
3	38	0	17.43	3.19	79.38	1017	18.70	3.62	77.68
3	39	10	17.09	3.64	79.27				
3	41	20	19.20	3.86	76.94	1018	18.91	4.23	76.86
3	42	30	19.04	3.95	77.01				
3	43	40	19.75	4.45	75.79	1019	20.56	4.88	74.56
3	44	50	21.78	3.75	74.47				
3	45	60	23.74	3.39	72.88	1147	23.05	3.70	73.25
3	46	70	25.78	3.51	70.71				
3	47	80	26.31	3.84	69.84	1038	26.42	4.37	69.20
3	48	90	28.51	4.40	67.09				
3	49	100	31.63	4.14	64.23	1021	28.59	4.67	66.74
3	51	110	28.09	3.98	67.93				
3	52	120	26.12	3.65	70.22	1022	27.13	3.91	68.96
3	53	130	26.78	3.91	69.30				
3	54	140	28.06	3.26	68.68	1023	28.92	3.33	67.74
3	55	150	27.82	2.70	69.48				
3	56	160	28.55	2.54	68.91				
3	57	170	28.38	2.16	69.46				
3	58	180	32.81	1.70	65.49				
3	59	190	27.77	1.51	70.72				
3	61	200	31.45	1.34	67.21				
3	62	210	30.98	1.46	67.56				
3	63	220	31.03	1.67	67.30				
3	64	230	33.07	1.75	65.18				
3	65	240	30.37	1.70	67.94				
3	66	250	29.78	2.09	68.13				
3	67	260	31.84	1.49	66.66				
3	68	270	30.98	1.36	67.66				
3	69	280	31.85	1.52	66.63				

Appendix C.
Description for profile no. 4

Core identification: 4
Soil type: Typic Hapludalf

Depth	Horizon	Description
0-19	Ap	Dark brown (10 YR 3/3) silt loam; weak, medium platy; friable; no reaction with HCl; few fine roots; abrupt smooth boundary to
19-40	A12	Dark brown (10 YR 3/3) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; few fine roots; few, faint mottles; clear smooth boundary to
40-65	B1	Dark brown (10 YR 4/3) silt loam; structureless massive to weak, coarse subangular blocky; firm; no reaction with HCl; few faint mottles; diffuse smooth boundary to
65-119	B2t	Dark brown (10 YR 3/4) silt loam; structureless massive to weak coarse subangular blocky; firm; no reaction with HCl; few fine manganese concretions; common moderately thick argillans (10 YR 4/2); diffuse boundary to
119-end	C	Dark brown (10 YR 3/4) silt loam to silty clay loam; structureless massive; firm; no reaction with HCl; few fine manganese concretions; common distinct mottles (7.5 YR 5/8); common distinct silans (10 YR 6/2); common moderately thick argillans (10 YR 4/2).

Appendix C.
Particle size data for profile no. 4

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt
4	107	0	18.11	3.74	78.15
4	108	10	18.50	3.88	77.63
4	109	20	19.09	4.17	76.74
4	111	30	21.75	4.47	73.78
4	112	40	22.68	4.10	73.22
4	113	50	24.33	3.66	72.00
4	114	60	24.69	3.42	71.89
4	115	70	26.12	3.04	70.84
4	116	80	25.45	3.18	71.37
4	117	90	25.53	3.12	71.34
4	118	100	26.08	3.19	70.73
4	1992	110	25.38	3.84	70.78
4	121	120	27.48	3.24	69.28
4	122	130	27.83	3.20	68.97
4	123	140	28.05	2.83	69.11
4	124	150	28.40	2.73	68.87
4	125	160	28.28	2.34	69.38
4	1993	170	28.30	1.43	70.27
4	1131	180	28.16	1.41	70.43
4	128	190	28.67	1.62	69.71
4	129	200	28.90	1.17	69.93
4	131	210	29.10	1.17	69.74
4	132	220	27.79	1.10	71.11
4	133	230	26.23	3.25	70.53
4	134	240	42.98	1.73	55.29
4	135	250	28.75	.92	70.33
4	136	260	28.23	.93	70.84
4	137	270	28.27	1.00	70.73
4	138	280	28.79	1.18	70.04
4	139	290	29.87	1.07	69.06

PSA No.	% Clay	% Sand	% Silt
1121	17.47	2.83	79.70
1122	18.75	4.30	76.95
1123	22.41	4.49	73.10
1124	23.71	3.87	72.42
1125	24.01	3.45	72.53
1126	24.47	3.58	71.95
1127	26.36	3.72	69.92
1128	27.04	3.04	69.92

Appendix C.
Description for profile no. 5

Core identification: 5
Soil type: Typic Hapludalf

Depth	Horizon	Description
0-8	Ap	Dark brown (10 YR 3/3) silt loam; weak, medium platy; very friable; no reaction with HCl; common fine roots; abrupt smooth boundary to
8-50	A12	Dark brown (10 YR 3/3) silt loam; weak, medium to coarse subangular blocky; friable; no reaction with HCl; common fine roots; clear smooth boundary to
50-112	B2t	Dark brown (10 YR 3/3) silt loam; weak to moderate coarse subangular blocky; friable to firm; no reaction with HCl; common fine manganese concretions (only below 1 m); common faint mottles; common silans; common thin argillans (10 YR 4/2); gradual smooth boundary to
112-end	C	Dark brown (10 YR 3/3) silty clay loam; moderate coarse subangular blocky; firm to very firm; no reaction with HCl; common fine manganese concretions; common distinct mottles (7.5 YR 5/6); common silans (10 YR 6/2); common thin argillans (10 YR 3/2, 10 YR 4/1).

Appendix C.
Particle size data for profile no. 5

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
5	1	0	17.69	4.36	77.95	1995	17.46	3.99	78.55
5	2	10	17.32	5.28	77.39				
5	3	20	18.07	4.70	77.23	1002	17.93	4.67	77.40
5	4	30	19.44	7.43	73.13				
5	5	40	21.40	5.38	73.22	1003	22.69	5.60	71.71
5	6	50	23.90	4.42	71.68				
5	7	60	24.71	4.15	71.14	1004	25.94	3.95	70.10
5	8	70	26.41	2.44	71.16				
5	9	80	26.00	3.59	70.41	1005	26.00	4.16	69.84
5	11	90	24.85	3.60	71.56				
5	12	100	25.59	4.06	70.35	1915	19.33	3.57	77.10
5	13	110	26.16	2.96	70.88				
5	14	120	26.19	3.36	70.45	1006	24.95	3.25	71.80
5	15	130	28.06	3.31	68.63				
5	16	140	27.76	7.06	65.17	1916	28.17	3.23	68.61
5	17	150	27.91	3.02	69.07				
5	18	160	28.67	2.53	68.80				
5	19	170	29.68	2.45	67.87				
5	21	180	30.47	1.78	67.75				
5	22	190	29.72	1.73	68.55				
5	23	200	29.63	1.34	69.03				
5	2012	210	27.79	1.86	70.34				
5	1011	220	28.92	1.42	69.67				
5	26	230	28.21	5.16	66.63				
5	27	240	28.85	.96	70.19				
5	28	250	28.70	.82	70.48				
5	29	260	29.95	.76	69.29				
5	31	270	27.59	1.01	71.40				
5	32	280	26.75	.89	72.36				
5	33	290	27.51	.78	71.71				
5	34	300	28.80	.49	70.71				
5	35	310	29.69	.55	69.76				
5	36	320	29.72	.47	69.80				
5	37	330	31.82	.62	67.56				

Appendix C.
Description for profile no. 6

Core identification: 6
Soil type: Typic Hapludalf

Depth	Horizon	Description
0-16	Ap	Dark brown (10 YR 3/3) silt loam; moderate, medium platy; friable; no reaction with HCl; few fine roots; abrupt smooth boundary to
16-40	A12	Dark brown (10 YR 3/3) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; clear smooth boundary to
40-58	B1	Dark brown (10 YR 3/3) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; very few fine manganese concretions; very few faint mottles; few thin argillans; gradual smooth boundary to
58-105	B2t	Dark brown (10 YR 3/3); silt loam to silty clay loam; friable; very few fine manganese concretions; very few distinct mottles (7.5 YR 5/6); few thin to moderately thick argillans; clear smooth boundary to
105-130	B3	Dark brown (10 YR 4/3) silt loam; structureless massive; common fine manganese concretions; common faint mottles; few thin argillans; clear smooth boundary to
130-end	C	Dark brown (10 YR 3/3) and dark yellowish brown (10 YR 4/4) silty clay loam; weak, medium subangular blocky; firm; common fine manganese concretions; common distinct mottles (7.5 YR 5/6); common silans (10 YR 5/2); few to common thin argillans.

Appendix C.
Particle size data for profile no. 6

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
6	178	0	16.55	4.87	78.58	1137	15.73	4.97	79.30
6	179	10	16.45	5.13	78.42				
6	181	20	18.21	4.79	77.00	1138	16.42	4.97	78.61
6	182	30	19.24	7.20	73.56				
6	183	40	20.50	7.18	72.32	1139	19.83	6.70	73.46
6	184	50	22.73	5.50	71.77				
6	185	60	25.84	5.04	69.12	1161	24.16	4.67	71.18
6	186	70	26.91	3.92	69.17				
6	187	80	27.43	3.11	69.46	1162	25.52	3.27	71.21
6	188	90	26.61	3.16	70.23				
6	189	100	26.41	2.71	70.89	1163	24.59	3.06	72.34
6	191	110	24.88	2.86	72.27				
6	192	120	25.30	2.55	72.16	1164	24.13	2.47	73.40
6	193	130	26.34	2.68	70.98				
6	194	140	27.28	2.97	69.75	1165	28.30	2.71	68.99
6	195	150	28.40	2.59	69.01				
6	196	160	29.09	2.58	68.33				
6	197	170	28.62	2.56	68.83				
6	198	180	28.91	1.93	69.16				
6	199	190	29.96	1.55	68.49				
6	201	200	28.72	1.55	69.73				
6	202	210	28.60	1.47	69.93				
6	203	220	28.35	1.11	70.54				
6	204	230	28.26	1.08	70.66				
6	205	240	28.21	.73	71.05				
6	206	250	29.42	.74	69.84				
6	207	260	29.70	.70	69.60				
6	208	270	29.65	.60	69.75				
6	209	280	30.30	.73	68.97				
6	211	290	31.00	.78	68.22				
6	212	300	30.86	.50	68.64				
6	213	310	31.71	.47	67.82				
6	214	320	30.89	.52	68.59				
6	215	330	31.17	.84	67.99				

Appendix C.
Description for profile no. 7

Core identification: 7
Soil type: Typic Hapludalf

depth	horizon	description
0-12	Ap	Dark brown (10 YR 3/3) silt loam; weak, medium platy; very friable; no reaction with HCl; common fine roots; abrupt smooth boundary to
12-35	A12	Dark brown (10 YR 3/3) silt loam; weak, medium subangular blocky; friable; no reaction with HCl; common fine roots; clear smooth boundary to
35-80	B2t	Dark brown (10 YR 3/3) silty clay loam; weak, medium subangular blocky; friable; no reaction with HCl; few fine roots; few fine manganese concretions; few to common thin argillans; clear smooth boundary to
80-135	B3	Dark brown (10 YR 4/3) silt loam; weak, medium to coarse subangular blocky; firm; common faint mottles; common silans (10 YR 6/2); few to common thin argillans; gradual smooth boundary to
135-end	C	Dark brown (10 YR 3/3) and dark yellowish brown (10 YR 4/4) silty clay loam; weak, coarse subangular blocky; very firm; few fine roots; common fine manganese concretions; common silans (10 YR 6/2); common distinct mottles (7.5 YR 4/4); common thin argillans (10 YR 4/2).

Appendix C.
Particle size data for profile no. 7

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
7	141	0	17.47	5.30	77.23	1174	15.18	5.81	79.01
7	142	10	18.22	6.02	75.76				
7	143	20	21.12	6.44	72.44	1175	19.90	6.23	73.87
7	144	30	23.95	4.58	71.47				
7	145	40	26.17	4.08	69.75	1176	23.93	3.89	72.18
7	146	50	27.07	3.74	69.19				
7	147	60	27.62	3.09	69.29	1177	24.60	3.14	72.25
7	148	70	27.83	2.93	69.24				
7	149	80	26.32	2.70	70.98	1178	23.36	2.90	73.74
7	151	90	26.35	2.70	70.95				
7	1179	100	23.19	2.82	73.99	1911	23.49	2.66	73.85
7	153	110	24.49	2.65	72.86				
7	154	120	24.60	2.56	72.84	1181	23.94	2.59	73.47
7	155	130	24.66	2.71	72.63				
7	156	140	26.05	2.87	71.07	1182	25.07	2.73	72.20
7	157	150	27.59	3.32	69.09				
7	158	160	27.56	2.70	69.75				
7	159	170	29.52	2.32	68.15				
7	161	180	29.72	1.82	68.46				
7	162	190	29.54	1.53	68.93				
7	163	200	29.92	1.31	68.77				
7	164	210	29.75	1.33	68.92				
7	165	220	28.38	.87	70.76				
7	166	230	28.52	1.37	70.11				
7	167	240	27.80	.69	71.51				
7	168	250	29.79	.62	69.60				
7	169	260	29.99	.64	69.37				
7	171	270	31.42	.73	67.84				
7	172	280	30.80	.54	68.67				
7	173	290	31.62	.43	67.95				
7	174	300	32.53	.46	67.01				
7	175	310	30.14	.69	69.17				
7	1996	320	32.44	.66	66.90				
7	177	330	46.46	.56	52.98				

Appendix C.
Description for profile no. 8

Core identification: 8
Soil type: Typic Hapludalf

Depth	Horizon	Description
0-13	Ap	Dark brown (10 YR 3/3) silt loam; weak, fine platy; very friable; no reaction with HCl; few fine roots; clear smooth boundary to
13-50	A12	Dark brown (10 YR 3/3) silt loam; very weak, coarse subangular blocky; friable; no reaction with HCl; gradual smooth boundary to
50-100	B2t	Dark brown (10 YR 3/3) silt loam; very weak, coarse subangular blocky; firm; no reaction with HCl; many thin argillans; gradual smooth boundary to
100-145	B3	Dark yellowish brown (10 YR 4/4) silt loam; structureless massive to very weak, coarse subangular blocky; firm; no reaction with HCl; few fine manganese concretions; common thin argillans;gradual smooth boundary to
145-end	C	Dark brown (10 YR 3/4) silty clay loam; structureless massive to very weak, coarse subangular blocky; firm to very firm; no reaction with HCl; few faint mottles; few silans (10 YR 6/2); few thin argillans.

Appendix C.
Particle size data for profile no. 8

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
8	216	0	17.01	5.28	77.71	1301	17.18	4.93	77.89
8	217	10	16.63	5.54	77.83				
8	218	20	17.60	5.95	76.45	1302	18.56	6.38	75.07
8	219	30	20.09	7.11	72.80				
8	221	40	21.60	5.06	73.34	1303	19.67	4.68	75.65
8	222	50	23.80	5.04	71.16				
8	223	60	26.87	3.48	69.65	1304	24.44	3.43	72.13
8	224	70	27.75	2.90	69.36				
8	225	80	27.86	2.57	69.57	1305	26.46	2.49	71.06
8	226	90	26.52	2.23	71.25				
8	227	100	25.25	2.46	72.29	1306	24.47	2.57	72.96
8	228	110	25.35	2.34	72.31				
8	229	120	25.69	2.42	71.89	1307	24.50	2.44	73.06
8	231	130	26.47	3.07	70.46				
8	232	140	26.56	3.16	70.28	1308	27.21	2.97	69.82
8	233	150	26.20	2.96	70.85				
8	234	160	26.82	2.81	70.37				
8	235	170	28.25	2.43	69.32				
8	236	180	29.43	1.88	68.69				
8	237	190	29.73	1.44	68.83				
8	238	200	28.71	1.36	69.93				
8	239	210	28.96	1.28	69.77				
8	241	220	28.88	1.02	70.10				
8	242	230	29.10	.96	69.94				
8	243	240	28.57	.88	70.55				
8	244	250	30.10	.83	69.07				
8	245	260	30.16	.69	69.15				
8	246	270	29.55	.78	69.67				
8	247	280	29.29	1.18	69.53				
8	248	290	29.71	.90	69.39				
8	249	300	31.40	.68	67.92				
8	1191	310	28.83	.80	70.36				
8	1192	320	29.83	.84	69.33				
8	1193	330	29.66	1.23	69.11				
8	1194	340	30.47	.60	68.93				

Appendix C.
Description for profile no. 9

Core identification: 9
Soil type: Typic Hapludalf

Depth	Horizon	Description
0-10	Ap	Very dark gray brown (10 YR 3/2) silt loam; weak medium platy; friable; no reaction with HCl; few fine roots; abrupt smooth boundary to
10-38	A12	Dark brown (10 YR 3/3) silt loam; weak, medium to coarse subangular blocky; friable; no reaction with HCl; clear smooth boundary to
38-84	B2t	Dark brown (10 YR 3/3, 10 YR 4/3) silt loam; weak, coarse subangular blocky; friable; no reaction with HCl; few thin argillans; clear smooth boundary to
84-132	B3	Dark brown (10 YR 3/3) silt loam; weak, coarse subangular blocky; friable to firm; no reaction with HCl; common fine manganese concretions; common silans (10 YR 6/2); common faint mottles; common thin argillans; gradual smooth boundary to
132-end	C	Dark brown (10 YR 3/3) silty clay loam; weak coarse subangular blocky; very firm; no reaction with HCl; common fine manganese concretions; common faint mottles; common silans (10 YR 6/2); common thin argillans (10 YR 3/2).

Appendix C.
Particle size data for profile no. 9

Core No.	PSA No.	Depth	% Clay	% Sand	% Silt	PSA No.	% Clay	% Sand	% Silt
9	71	0	17.59	4.92	77.49	1032	17.95	5.05	77.00
9	72	10	18.19	5.29	76.51				
9	73	20	20.75	5.76	73.49	1033	21.06	5.86	73.07
9	74	30	20.83	5.57	73.60				
9	75	40	24.82	4.39	70.78	1034	24.65	4.75	70.60
9	76	50	25.54	3.48	70.98				
9	77	60	26.29	2.96	70.75	1035	26.48	3.21	70.32
9	78	70	26.74	2.63	70.62				
9	79	80	26.77	2.28	70.95	1036	26.44	2.42	71.14
9	81	90	24.71	2.14	73.15				
9	82	100	24.37	2.81	72.82	1037	24.84	2.66	72.50
9	83	110	25.33	2.77	71.90				
9	2014	120	24.42	3.17	72.40	1039	25.83	2.76	71.40
9	85	130	28.26	3.23	68.51				
9	2015	140	28.11	3.45	68.43	1997	27.68	3.11	69.22
9	87	150	28.12	3.13	68.75				
9	88	160	29.25	2.56	68.19				
9	89	170	30.45	1.93	67.62				
9	91	180	31.01	1.60	67.39				
9	92	190	29.97	1.26	68.77				
9	93	200	29.93	1.07	69.00				
9	94	210	29.87	1.10	69.03				
9	95	220	28.81	1.71	69.48				
9	96	230	31.22	.92	67.86				
9	97	240	31.07	.66	68.27				
9	1998	250	29.62	.88	69.50				
9	99	260	31.46	.94	67.60				
9	101	270	31.41	.74	67.85				
9	102	280	32.47	.51	67.02				
9	103	290	32.46	.30	67.24				
9	104	300	31.83	.27	67.89				
9	105	310	32.56	.40	67.04				
9	106	320	32.24	.73	67.03				

Appendix C
Thin section point count data

Core	Depth	Photomicrograph 1	2	3	4	5	Sum	% Clay
3	10	0 (9)	0 (1)	0 (15)	0 (9)	0 (3)	0 (37)	0.000
3	30	0 (12)	0 (20)	0 (0)	2 (111)	0 (0)	2 (143)	.179
3	60	0 (0)	11 (0)	1 (0)	9 (0)	2 (0)	23 (0)	1.825
3	90	21 (0)	10 (3)	12 (0)	35 (0)	12 (0)	90 (3)	7.160
3	130	7 (29)	14 (4)	5 (6)	2 (0)	9 (4)	37 (43)	3.040
3	180	4 (1)	21 (4)	15 (5)	6 (31)	4 (5)	50 (46)	4.119
3	210	14 (10)	16 (8)	9 (20)	28 (2)	15 (5)	82 (45)	6.749
3	240	4 (6)	5 (1)	8 (42)	39 (11)	2 (7)	58 (67)	4.862
3	260	21 (12)	23 (14)	22 (20)	17 (13)	13 (0)	96 (59)	7.993
3	300	12 (11)	9 (10)	4 (5)	11 (16)	8 (2)	44 (44)	3.618

Appendix C
Thin section point count data

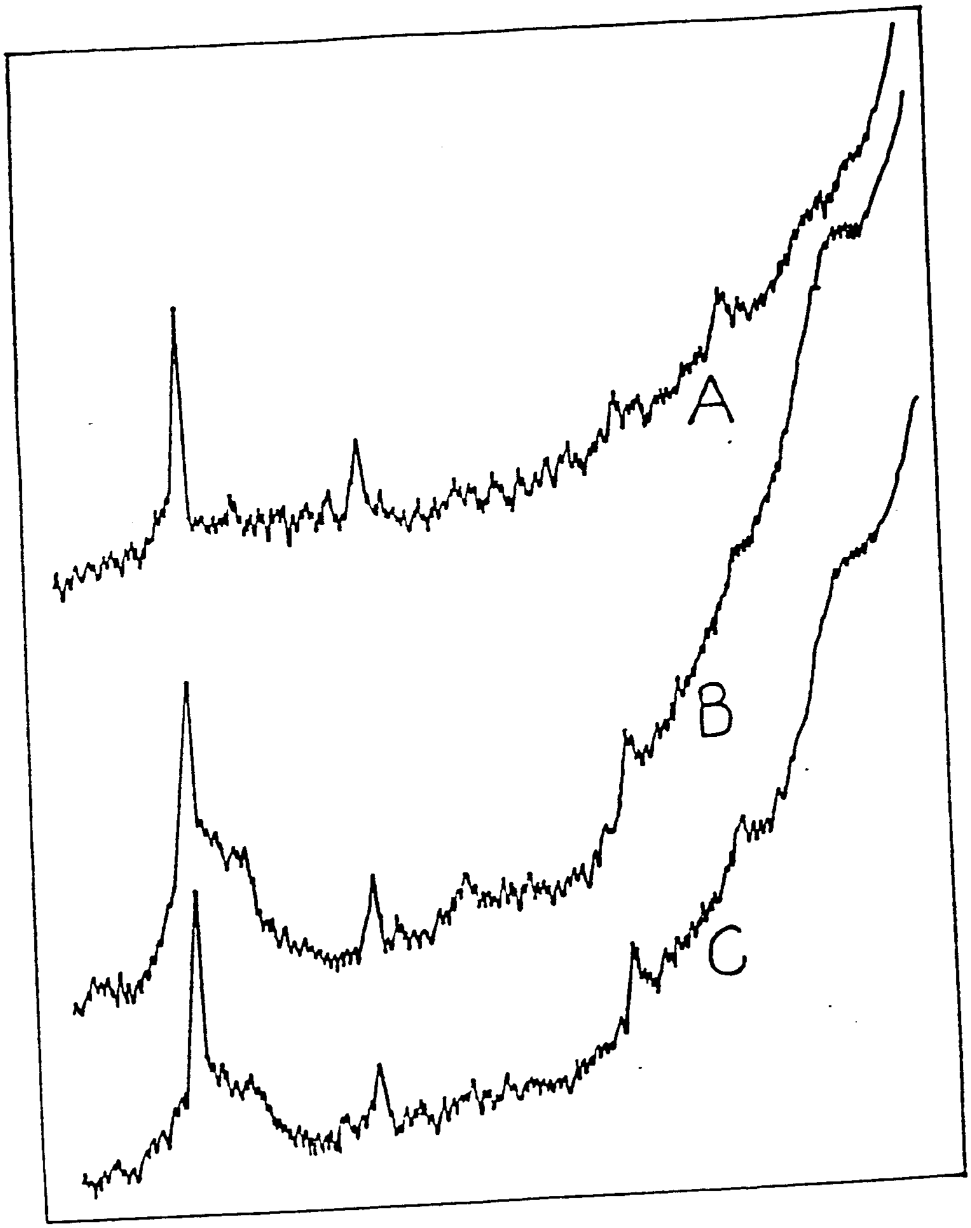
Core	Depth	Photomicrograph 1	2	3	4	5	Sum	% Clay
9	10	2 (9)	3 (4)	0 (19)	0 (1)	0 (2)	5 (35)	.408
9	30	1 (43)	3 (61)	6 (8)	2 (11)	2 (32)	14 (155)	1.267
9	60	10 (1)	6 (20)	0 (4)	8 (25)	0 (2)	24 (52)	1.987
9	90	12 (4)	3 (0)	11 (14)	4 (4)	20 (12)	50 (34)	4.078
9	140	8 (0)	3 (4)	1 (0)	14 (4)	19 (7)	45 (15)	3.614
9	180	46 (33)	0 (1)	13 (22)	32 (20)	21 (23)	112 (99)	9.647
9	210	9 (1)	8 (18)	7 (1)	14 (0)	18 (20)	56 (40)	4.590
9	240	8 (13)	2 (0)	7 (9)	2 (1)	3 (6)	22 (29)	1.787
9	260	15 (7)	25 (60)	5 (2)	8 (6)	3 (0)	56 (75)	4.726
9	300	0 (0)	22 (12)	2 (0)	0 (0)	11 (3)	35 (15)	2.811

Thin section point counts. The upper line for each profile/depth combination indicates total points with oriented clay. The lower line, with values in parentheses, indicates total points with voids. Depth is given in centimeters.

A transparent grid (28 x 36 mm) with lines 2mm apart was placed over each photomicrograph. Presence or absence of oriented clay(or voids) was noted at each grid intersection (see Section 2.2.4). Percent oriented clay for each profile and depth combination was calculated by summing the number of points with clay across five photomicrographs, dividing by the total number of grid intersections (14 x 18 x 5) minus the total number of intersections with voids and multiplying by 100.

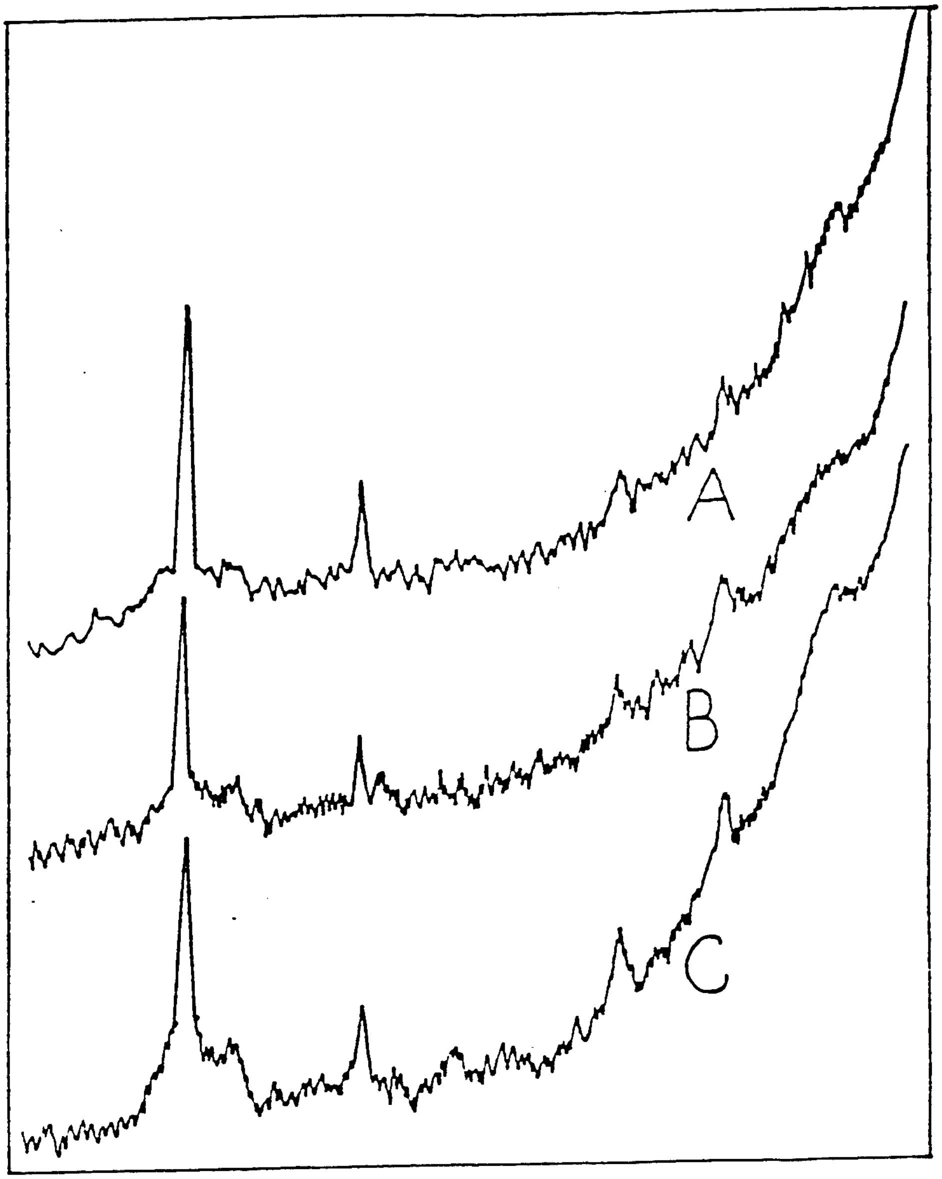
% oriented clay =(total points with clay/(1260-total points with voids))*100

Appendix C.
Clay mineralogy for profiles 3 and 9



Clay mineralogy for profile no. 3. The figure shows the x-ray diffractogram for the clay fraction in the A horizon (sample taken between 10 and 20 cm), the B horizon (100-110 cm), and the C horizon (200-210). The sharp peak on the left is quartz. Rounded peaks at the extreme right (most obvious in B and C horizons) represent montmorillonite.

Appendix C.
Clay mineralogy for profiles 3 and 9



Clay mineralogy for profile no. 9. The B horizon sample came from 60-70 cm, with A and C samples from 10-20 and 200-210 respectively. The mineralogy of profile 9 is very similar to profile 3, suggesting that the parent material of the soil at both ends of the moisture gradient is the same.

Appendix D

This appendix contains soil profile descriptions and soil laboratory data for profiles 78B and 78C, Koch Spring area, lower Pomme de Terre valley.

SOIL DESCRIPTION

CLASSIFICATION: Typic Hapludalf
IDENTIFIER: Trench 78B (of Haynes 1981)
LOCATION: Approximately 30 m SE of Council tree, due S. of Koch Spring, Pomme de Terre River, Hickory Co., MO.
LEGAL DESCRIPTION: NE ¼, SW ¼, NE ¼, Sec. 15, T38N, R22W, Hickory Co., MO.
GEOMORPHIC SURFACE: T-lb terrace (of Haynes 1976, 1981)
LANDFORM: River terrace
PARENT MATERIAL: Alluvium
SLOPE: 1-2° (1-3%)
ELEVATION: Approximately 706 feet (215 m)
VEGETATION: Weeds in abandoned cultivated field; originally oak-hickory forest
SAMPLED BY: D.L. Johnson and D. Watson Stegner, 8/9/78
DESCRIBED BY: D.L. Johnson and D. Watson Stegner, 8/9/78
EXPOSURE: Backhoe trench

HORIZON	DEPTH (cm)	DESCRIPTION
A_p	0-20	Dark brown (10YR 3/3m; 6/3d) silt loam; weak very fine and fine platy (0-12 cm), and weak, medium and coarse subangular blocky (12-20 cm) structure; very friable; abundant chert debitage flakes and fire oxidized sandstone and chert; very many very fine, and few medium and coarse pores; common to many fine roots; abrupt smooth boundary.
A_1	20-34	Dark brown (10YR 3.5/3m; 6/3d) silt loam; weak to moderate fine platy structure; friable; many earthworm (?) and grass-root channelways; common small krotovina (≤ 3 mm dia.); common chert debitage flakes, and fire oxidized sandstone and chert; very many very fine, and few medium and coarse, pores; few fine roots; clear wavy boundary.
A_2	34-49	Dark brown (10YR 4/3m; 6/3d) silt loam; very weak, fine platy parting to moderate medium subangular blocky structure; friable; many krotovina (≤4 mm), biochannelways, and fecal pellets; abundant chert debitage flakes, charcoal, and a projectile point at 35 cm; a few thin silans (< 2%); very many very fine, and common medium and large pores, moderately vesicular; few fine roots; clear wavy boundary.
B_1	49-70	Dark brown (10YR 4/3m; 6/4d) heavy silt loam; moderate medium subangular blocky structure; friable to firm; common thin silans (2-20%); abundant krotovinas (≤8 mm); few to common thin clay skins; abundant chert debitage flakes, oxidized sandstone and other rocks; Smith point at 59 cm; many very fine, and few medium pores; few fine roots; clear wavy boundary.

B_{21t}	70-110	Dark brown (10YR 4/3m; 6/4d) heavy silt loam; faint to weak medium and coarse prismatic in place, parting to strong medium and coarse subangular blocky structure; very to extremely firm; many thin clay skins on peds, pore walls, and along bio-channelways; common pale silans, especially along vertical ped faces; charcoal; very many very fine and medium, and common to many coarse pores; few fine roots; gradual wavy boundary.
B_{22t}	110-155	Dark brown (10YR 4/3m; 6/4d) heavy silt loam; faint medium and coarse prismatic in place, parting to moderate medium and coarse subangular blocky structure; very firm; common thin clay skins on ped faces, in pores, and in bio-channelways; many thin silt-coatings on ped faces and in bio-channelways; common krotovina ($\lesssim$3 mm dia.); few to common thin MnO_2 films; very many very fine and fine pores; few fine roots; clear wavy boundary.
B_3	155-241	Dark brown (10YR 4/3m; 6/4d) heavy silt loam; weak coarse prismatic in place, parting to moderate medium and coarse subangular blocky structure; firm; many thin silt coatings on ped surfaces, and in bio-channelways; common to few thin clay skins, decreasing in coverage with depth; common krotovina ($\leq$10 mm dia.); very many very fine and fine, and common medium pores; few fine roots; gradual wavy boundary.
C_1	241-280+	Dark brown (10YR 4/3m; 6/4d) silty clay loam; very weak coarse prismatic in place, parting to moderate medium subangular blocky structure; firm; few to common thin clay skins and silt coatings; charcoal; many very fine and fine pores; few fine roots.

Comments: Radiocarbon dates on charcoal taken from this trench were made at 40 cm depth (A_2 horizon), 85 cm (B_{21t}) and 270 cm (C_1) which gave ages, respectively, of 3680±100 (SMU-823), 5110±280 (SMU-816), and 7990±120 (SMU-814) RYBP.

SOIL DESCRIPTION

CLASSIFICATION: Typic Albaqualf
IDENTIFIER: Trench 78C (of Haynes 1981)
LOCATION: Approximately 30 m E. of W. bluff of Pomme de Terre valley, about 250 m so. of Koch Spring, Hickory Co., MO.
LEGAL DESCRIPTION: NE 1/4, SW 1/4, NW 1/4, NE 1/4, Sec. 15, T38N, R22W, Hickory Co
GEOMORPHIC SURFACE: T-16 terrace (of Haynes 1976, 1981)
LANDFORM: River terrace
PARENT MATERIAL: Alluvium (Rodgers (1.2 m) over Koch alluviums)
SLOPE: 1-2° (1-3%)
ELEVATION: Approximately 706 feet (215 m)
VEGETATION: Weeds in abandoned cultivated field; originally oak-hickory forest
SAMPLED BY: D.L. Johnson, 8/17/78
DESCRIBED BY: D.L. Johnson, 8/17/78
EXPOSURE: Backhoe trench

HORIZON	DEPTH (cm)	DESCRIPTION
A_{pg}	0-15	Dark grayish brown (10YR 4/2m; 7/2d) silt loam, with common fine faint mottles (10YR 4/4m) in matrix and along bio-channelways; very weak, fine platy to weak medium subangular blocky structure; friable; common fecal pellets; many fine and very fine pores; many fine roots; abrupt smooth boundary.
A_{1g}	15-28	Dark grayish brown (10YR 4/2m; 7/2d) silt loam, with common fine faint (10YR 4/4m) mottles in matrix and along bio-channelways; moderate to strong medium platy structure; friable; common fecal pellets; many fine and very fine pores; many fine roots; abrupt wavy boundary.
A_{2g}	28-47	Grayish brown (10YR 5/2m; 7/2d) silt loam, with common to many fine and medium faint mottles (10YR 4/4m) weak fine platy structure; friable; many small krotovina ($\leq$3-4 mm dia.) and fecal pellets; few MnO_2 concretions (< 3 mm dia.); very many very fine, and few medium and coarse pores and vesicles; few to common fine and very fine roots; clear wavy boundary.
B_{1g}	47-75	Dark grayish brown (10YR 4.5/2m; 7/2d) silt loam, with common medium distinct mottles (7.5YR 4/6m) in matrix; weak to moderate medium prismatic structure in place, parting to weak to moderate subangular blocky structure; friable; common small krotovina, some fecal pellets; common MnO_2 pelletoid concretions; very many very fine, and few medium pores; few fine roots; clear wavy boundary.

B_{21tg}	75-121	Dark grayish brown (10YR 4/2m; 7/2d) silty clay loam, with common to many medium distinct and prominent mottles (5YR 3/4m; 7.5YR 3/4d); weak to moderate medium prismatic in place, parting to weak to moderate medium subangular blocky structure; friable; common blackish MnO_2 pellets (~2 mm dia.) and films; common very thin clay films; very many very fine pores; few fine roots; gradual wavy boundary.
IIB_{22tbg}	121-148	Dark grayish brown (10YR 4/2m; 6/4d) silty clay, with many medium and coarse distinct and prominent mottles (5YR 3/4m; 7.5YR 3/4d) in matrix; massive to weak medium and coarse subangular blocky structure; friable; common to many blackish MnO_2 pellets (~2 mm dia.) and films; abundant slickensides; many very fine pores; few fine roots; clear wavy boundary.
IIB_{23tbg}	148-178+	Dark grayish brown (10YR 4/2m; 6/4d) silty clay, with many medium and coarse distinct and prominent mottles (5YR 3/4m; 7.5YR 3/4d) in matrix; massive, parting to weak medium and coarse subangular blocky structure; friable; common to many blackish MnO_2 pellets and films; few slickensides; common very fine pores; few fine roots.

Comments: A flake was found at 100 cm depth (39.4 inches) in a nearby pedon in this trench.

Particle Size Data for Koch Spring Area Trenches 78B, 78C.

cm Depth	78B % Sand	78B % Silt	78B % Clay	78C % Sand	78C % Silt	78C % Clay
0-10	6.4	76.1	17.5	6.1	77.3	16.6
10-20	5.9	80.4	13.7	3.5	79.8	16.7
20-30	4.9	79.7	15.4	3.2	81.0	15.8
30-40	5.8	78.0	16.2	3.9	81.3	14.8
40-50	5.3	76.6	18.1	3.7	75.8	20.5
50-60	20.8	61.7	17.5	3.9	70.3	25.9
60-70	5.9	72.4	21.7	3.1	69.2	27.7
70-80	7.6	67.5	24.9	4.2	68.9	26.9
80-90	8.5	65.7	25.8	4.8	67.8	27.4
90-100	8.5	65.4	26.1	4.1	65.0	31.0
100-110	7.3	67.1	25.6	5.3	62.6	32.1
110-120	5.6	68.9	25.5	4.7	60.5	34.8
120-130	5.4	68.9	25.7	4.6	57.5	37.9
130-140	4.5	70.1	25.4	4.8	52.0	43.2
140-150	4.1	69.7	26.2	3.9	54.0	42.1
150-160	4.1	71.3	24.6	4.1	53.3	42.6
160-170	3.9	74.8	21.1	7.4	54.5	38.1
170-180	3.8	70.8	25.4			
180-190	4.5	73.0	22.5			
190-200	5.8	67.6	26.6			
200-210	6.6	68.4	25.2			
210-220	7.0	65.9	27.2			
220-230	8.0	66.2	25.9			
230-240	5.5	67.1	27.4			
240-250	7.8	64.7	27.5			
250-260	6.9	64.5	28.6			

Appendix E

This appendix contains soil descriptions, and physical and chemical laboratory data for the Montgomery Site, Sac River, Cedar County, Missouri.

CLASSIFICATION: Argiaquic Argialboll
IDENTIFIER: Montgomery Site T-trench (Cut-Bank Site); Pedon A
LOCATION: 2½ miles (4 km) NE of town of Stockton, in field just W. of large meander bend of Sac River, Cedar Co., Mo.
GEOGRAPHIC COORDINATES: 37° 43' 15" N. lat., 93° 45' 21" W. Long.
GEOMORPHIC SURFACE: T-1b terrace (of Haynes 1976, 1981)
LANDFORM: River terrace (Holocene)
PARENT MATERIAL: Alluvium (Holocene)
SLOPE: 0-2° (0-3%)
DRAINAGE: Imperfectly to poorly drained
ELEVATION: Approximately 785 feet (239 m)
VEGETATION: Cropped corn
SAMPLED BY: D.L. Johnson and D. Watson Stegner 7/15/77
DESCRIBED BY: D.L. Johnson and D. Watson Stegner 7/15/77
EXPOSURE: Backhoe T-trench

HORIZON	DEPTH (cm)	DESCRIPTION
A_p	0-15	Dark brown (10YR 3/3m; 5/3d) silt loam; weak to moderate medium and coarse platy structure; friable; few fine pores; common fine roots; clear smooth boundary.
A_{12}	15-27	Dark brown (10YR 3/3m; 5/3.5d) silt loam; moderate coarse subangular blocky structure; friable; common to many very fine and fine pores; common fine roots; clear smooth boundary.
A_{13}	27-45	Very dark grayish brown (10YR 3/2m; 4/2d) silt loam; moderate coarse subangular blocky structure; friable; few to common small krotovina (4 mm dia.); common to many very fine and fine pores; few to common fine roots; abrupt to clear smooth boundary.
A_{2g}	45-66	Dark grayish brown (10YR 4/2m; 6/2d) silt loam; weak to moderate coarse subangular blocky structure; friable (hard when dry); few fine faint mottles; many thick silt coatings on ped faces, in pores and in matrix; few fine MnO_2 pellets; very many very fine and fine pores; common fine roots; clear smooth boundary.
B_{1g}	66-90	Dark grayish brown (10YR 4/2m; 5.5/2.5d) silty clay loam; weak to moderate medium and coarse subangular blocky structure; friable (hard when dry); few fine faint mottles; few fine MnO_2 pellets; common moderately thick silt coatings in matrix, pores and some ped faces; few thin dark clay skins in pores; many very fine and fine pores; common fine roots; clear smooth boundary.

B_{2tg}	90-125	Very dark grayish brown (10YR 3/2m; 5.5/3d) silty clay loam; moderate coarse subangular blocky structure; friable (hard when dry); few to common fine distinct mottles; common fine MnO_2 pellets; common to many very dark moderately thick clay skins in pores and along ped faces; common silt coatings in matrix; many very fine and fine pores; common fine roots; clear smooth boundary.
B_{3g}	125-165	Dark grayish brown (10YR 4/2; 6/2.5d) silty clay loam; massive to weak coarse subangular blocky structure; friable (very hard when dry); many fine to medium MnO_2 concentrations; common to many fine and medium distinct mottles; many thick silt coatings within peds; very few very thin clay skins; many very fine and fine pores; few fine roots; clear smooth boundary.
C_{1g}	165-215	Brown and dark brown (10YR 4/3m; 6/3d) silty clay loam; massive to very weak coarse subangular blocky structue; friable (hard to very hard when dry); many medium and coarse distinct mottles; few to common fine and medium MnO_2 concretions; few thin dark clay skins in pores; many very fine and fine pores; few fine roots; gradual irregular boundary.
C_2	215-320	Brown (10YR 5/3m; 6/3d) silt loam to loam; massive; friable (very hard when dry); many medium and coarse distinct and prominent mottles; few to common fine and medium MnO_2 concretions; few to common thin dark clay skins in pores; krotovina (crayfish?) present; many very fine and fine pores; few fine roots; essentially the same as the C_2 horizon.
IIC_3	320-360+	Except for change in parent material, same as C_2.

Comments: A Dalton (paleo-Indian) component layer occurs at about 3.0 depth in nearby pedons. The Sac River here has created a near vertical cut-bank on the west side; abundant in-situ cultural materials, including at least one Dalton point, have been collected here. New material is exposed as the river cuts westward. A C-14 date of 9,800±120 RYBP (SMU-444) was made on charcoal collected at 4.77m depth in a reduced clay matrix exposed in the cut-bank (37^{o} 43^{o} 20" N. Lat., 93^{o} 45' 24" W. Long.).

In another nearby pedon to the east of the one described here, a zone of clay skin density was noted at a depth of 170-285 cm.

CLASSIFICATION: Aquic Argiudoll
IDENTIFIER: Montgomery Site (Core Site) (Cut-Bank Site); Pedon B
LOCATION: 2½ miles (4 km) NE of town of Stockton, Mo., in field near bluff edge on W. side of Sac River at large meander bend, Cedar Co.
GEOGRAPHIC COORDINATES: 37° 43' 10" N. Lat., 93° 45' 21" W. Long.
GEOMORPHIC SURFACE: T-1b terrace (of Haynes 1976, 1981)
LANDFORM: River terrace (Holocene)
PARENT MATERIAL: Alluvium (Holocene)
SLOPE: 0-2° (0-3%)
DRAINAGE: Moderately well to imperfectly drained
ELEVATION: Approximately 785 feet (239m)
VEGETATION: In corn
SAMPLED BY: D.L. Johnson and M.V. Miller, August 1977
DESCRIBED BY: D.L. Johnson and M.V. Miller, August 1977
EXPOSURE: Giddings hydraulically extracted 2¾ inch (7 cm) dia. core

HORIZON	DEPTH (cm)	DESCRIPTION
A_p	0-20	Very dark grayish brown (10YR 3/2m; 5/2d) silt loam; moderate fine platy structure; friable (slightly hard when dry); common very fine faunal pellets; many very fine and fine pores; common fine and medium roots; abrupt smooth boundary.
A_{12}	20-36	Very dark brown (10YR 2/2m; 5/2d) silt loam; weak fine and medium subangular blocky structure; friable (hard when dry); many very fine faunal pellets; many fine and medium pores; few fine roots; abrupt wavy boundary.
A_2/A_3	36-80	Very dark grayish brown to brown to dark brown (10YR 3/25m; 5/2d) silt loam; weak fine and medium subangular blocky structure; friable (hard when dry); common to many thin silt coatings in lower horizon; very many very fine and fine pores, and a few medium and coarse ones; few fine roots; clear wavy boundary.
B_1	80-98	Dark brown (10YR 3/3m; 5/3d) silty clay loam; moderate medium subangular blocky structure; friable (very hard when dry); few thin clay skins on some ped faces; few thin silt coatings in pores; common very fine, fine and medium pores; few fine roots; gradual smooth boundary.
B_{21t}	98-125	Dark brown (10YR 3/3m; 5/3d) silty clay loam; moderate to strong medium subangular blocky structure; friable (very hard when dry); many moderately thick clay skins long ped faces and in pores; few fine distinct mottles; few silt coatings along ped faces and in pores; common fine and medium pores, and a few coarse ones; few fine roots; gradual irregular boundary.

B_{22t}	125-223	Dark brown to brown (10YR 4/3m; 6/4d) silty clay loam; weak medium prismatic parting to moderate to strong medium subangular blocky structure; friable (very hard when dry); common medium faint mottles; many moderately thick clay skins on ped faces and some pores; few to common thin silt coatings in some pores and in matrix; few to common very fine and medium pores; few fine roots; gradual irregular boundary.
B_3	223-284	Dark yellowish brown (10YR 4/4m; 6/4d) silt loam; weak medium prismatic parting to weak coarse subangular blocky structure; friable (very hard when dry); common to many moderately thick and thick grayish and dark clay skins in pores (mainly) and on ped faces; common thin silt coatings in pores, (mainly) and in matrix; few fine and medium faint mottles; many fine, medium and coarse pores (tubular and branched); few fine roots; gradual irregular boundary.
C_1	284-370	Dark yellowish brown (10YR 4/4m; 6/4.5d) silt loam; weak medium and coarse subangular blocky structure; friable (very hard when dry); many very dark (blackish) and grayish moderately thick and thick clay skins in coarse pores; few silt coatings in some pores and matrix; common to many medium and coarse faint mottles; common medium and coarse tubular dendritic pores; clear wavy boundary.
IIC_2	370-400+	Dark yellowish brown (10YR 4/4m; 6/4.5d) silty clay loam to loam; massive to weak medium and coarse subangular blocky structure; friable (very hard when dry); very many black very thick clay-humus skins in coarse tubular pores; few to common medium and coarse tubular dendritic pores.

Comments: This core, Pedon B, was pulled immediately above and through the Dalton component layer (C_1). The dark clay-humus coatings in coarse pores deep in the profile (C_1, IIC_2) are visible all along the cut bank of the Sac River, where they were observed wet and glistening, as though still forming. Also, many krotovina (presumably crayfish) are visible in the lower profile (B_3-IIC_2) along the cut bank.

Particle Size Data for Pedon A, Montgomery (Cut Bank) Site, Sac River, Cedar Co.,

cm	%		
Depth	Sand	Silt	Clay
0-10	0.7	76.5	22.8
10-20	0.4	75.8	23.8
20-30	0.4	75.5	24.1
30-40	0.9	75.7	23.4
40-50	1.4	79.4	19.2
50-60	2.0	81.0	17.0
60-70	3.5	74.8	21.7
70-80	2.9	67.9	29.2
80-90	3.4	65.2	31.4
90-100	4.5	62.4	33.1
100-110	3.5	62.9	33.6
110-120	3.3	63.9	32.9
120-130	3.2	65.2	31.6
130-140	2.8	67.1	30.1
140-150	3.8	65.2	31.0
150-160	3.4	65.5	31.1
160-170	2.6	64.1	33.3
170-180	2.5	62.7	34.8
180-190	2.6	63.0	34.5
190-200	3.0	63.1	33.9
200-210	3.5	64.3	32.2
210-220	2.7	65.3	32.0
220-230	2.7	64.0	33.3
230-240	2.7	66.0	31.2
240-250	1.7	61.5	36.7
250-260	2.2	68.0	29.8
260-270	1.7	67.1	31.2
270-280	2.2	63.6	34.2
280-290	3.5	64.5	32.1
290-300	4.4	64.4	31.3
300-310	7.3	63.1	29.6
310-320	10.2	60.3	29.6
320-330	10.7	63.0	26.3
330-340	15.0	56.8	28.2
340-350	22.0	53.2	24.6
350-360	29.3	47.2	23.4

Appendix E

Chemical Data for Pedon A, Montgomery (Cut Bank) Site, Sac River, Cedar Co., MO.

cm Depth	ppm P_2	pH	% o.m.	CEC	% B.S.	ppm/% Hydrogen	Potassium	Magnesium	Calcium
0-10	30	6.8	3.8	12.3	97	3.3	1.6	13.9	81.3
10-20	25	6.8	3.1	11.4	97	2.6	1.3	13.2	83.3
20-30	27	6.7	2.7	11.7	97	4.3	1.1	11.0	83.3
30-40	10	6.8	2.9	11.4	96	2.6	0.9	11.0	85.5
40-50	7	7.0	2.0	9.1	97	0.0	1.1	11.0	87.9
50-60	5	7.1	0.9	7.5	100	0.0	1.3	12.2	86.7
60-70	5	7.4	1.2	10.5	100	0.0	1.2	15.1	83.3
70-80	7	7.2	1.0	13.7	100	0.0	1.1	18.6	80.3
80-90	7	7.1	1.3	14.4	100	0.0	1.2	19.1	79.9
90-100	9	7.0	1.2	14.9	99	0.7	1.2	21.0	77.2
100-110	13	6.7	1.4	14.4	96	4.2	1.4	19.7	74.7
110-120	13	6.5	1.2	14.8	93	7.4	1.3	20.3	70.9
120-130	18	6.6	1.2	15.3	94	5.9	1.4	20.7	71.9
130-140	20	6.7	1.2	14.5	95	4.8	1.4	21.6	72.4
140-150	20	6.8	1.3	14.4	97	2.8	1.4	21.1	74.7
150-160	21	6.8	1.2	14.5	97	2.8	1.5	21.8	74.1
160-170	25	6.8	1.2	15.4	97	3.2	1.8	21.6	73.1
170-180	26	6.8	1.0	15.5	97	3.2	1.8	22.3	72.6
180-190	24	6.8	0.9	15.0	97	2.7	2.0	21.7	73.3
190-200	24	6.9	1.0	14.5	99	1.4	2.1	22.7	74.1
200-210	25	7.0	1.0	14.4	99	0.7	2.1	22.6	74.7
210-220	24	6.8	1.1	14.8	97	2.7	2.1	22.2	72.6
220-230	24	6.8	1.1	14.5	97	2.8	2.2	22.7	72.4
230-240	22	6.9	1.0	14.3	98	1.4	2.1	23.3	73.4
240-250	25	6.8	1.1	15.6	97	3.2	2.3	22.7	72.1
250-260	26	6.8	1.0	15.2	97	3.3	2.2	22.2	72.4
260-270	28	6.8	1.1	15.1	97	3.3	2.1	21.8	72.8
270-280	29	6.9	1.1	15.3	99	1.3	2.2	23.1	73.5
280-290	33	6.8	0.8	14.8	97	2.7	1.9	22.5	72.6
290-300	37	6.8	0.8	14.5	97	2.8	2.1	22.7	72.4
300-310	38	6.7	0.7	15.1	95	4.6	2.0	22.4	71.2
310-320	41	6.8	0.9	14.9	97	2.7	2.0	22.9	72.1
320-330	39	7.0	0.8	14.3	99	0.7	1.9	23.6	73.4
330-340	42	6.8	0.4	14.1	97	2.8	2.0	22.5	72.7
340-350	41	6.8	0.9	12.4	97	3.2	1.9	22.5	72.6
350-360	39	6.6	0.7	13.5	94	5.9	2.0	21.6	70.4

Particle Size Data for Pedon B, Montgomery (Cut Bank) Site, Sac River, Cedar Co., MO

cm Depth	Sand	% Silt	Clay
0-10	4.5	75.1	20.5
10-20	3.9	74.2	21.9
20-30	4.1	72.8	23.1
30-40	6.6	68.8	24.6
40-50	6.9	68.8	24.4
50-60	4.6	72.7	22.7
60-70	4.8	69.2	26.0
70-80	4.7	68.7	26.6
80-90	4.8	65.5	29.7
90-100	3.2	66.5	30.3
100-110	5.1	73.3	21.7
110-120	4.8	61.4	33.8
120-130	4.8	62.4	32.8
130-140	5.4	60.7	33.9
140-150	3.9	66.6	29.6
150-160	4.2	66.5	29.3
160-170	5.4	66.2	28.4
170-180	4.2	67.8	28.0
180-190	3.7	67.0	29.3
190-200	2.6	66.1	31.3
200-210	3.3	63.6	33.1
210-220	2.0	65.1	32.9
220-230	0.2	66.6	33.2
230-240	1.2	64.7	34.2
240-250	2.0	65.0	33.0
250-260	0.5	65.2	34.3
260-270	0.0	65.3	35.6
270-280	0.9	65.3	33.8
280-290	2.2	60.9	36.9
290-300	2.6	62.0	35.4
300-310	3.4	62.0	34.7
310-320	3.8	62.5	33.7
320-330	4.6	60.7	34.7
330-340	5.7	62.3	32.1
340-350	7.9	62.0	30.1
350-360	7.6	61.3	31.1
360-370	7.0	61.8	31.2
370-380	11.7	57.8	30.5
380-390	20.2	51.8	28.0
390-400	31.8	42.7	25.5

Appendix F

This appendix contains particle size analysis data for the Wolf Creek and Hand sites, near Osceola on the Osage River, Missouri.

Particle Size Data for Wolf Creek and Hand Sites, on Osage River near Oseola and Lowry City, St. Clair Co., MO.

	Wolf Creek Site			Hand Site		
		%			%	
cm Depth	Sand	Silt	Clay	Sand	Silt	Clay
0-10	5.7	63.4	30.9	13.8	64.9	21.3
10-20	0.4	63.8	35.9	12.8	65.3	21.9
20-30	5.4	62.0	32.4	15.5	63.5	21.1
30-40	5.9	63.1	31.0	25.3	51.2	23.4
40-50	2.8	66.1	31.2	12.9	60.1	27.8
50-60	8.5	62.4	29.1	12.2	61.0	26.8
60-70	9.1	60.4	30.6	27.6	46.5	25.9
70-80	9.4	63.5	27.1	6.0	69.7	24.4
80-90	9.2	65.1	25.7	5.1	65.0	29.9
90-100	6.8	65.5	27.7	6.0	63.8	30.2
100-110	8.9	63.1	28.0	6.0	64.0	30.0
110-120	9.2	61.1	29.7	4.9	63.3	31.8
120-130	8.6	62.1	29.4	6.5	59.2	34.4
130-140	5.1	62.6	32.3	3.8	61.7	34.5
140-150	6.3	61.0	37.7	3.3	61.9	34.8
150-160	4.6	59.6	35.9	4.5	61.6	34.0
160-170	4.7	59.4	35.8	3.0	61.1	36.0
170-180	5.1	54.1	40.8	3.8	62.4	33.8
180-190	5.0	57.1	37.9	4.1	63.1	32.9
190-200	2.9	57.9	39.3	4.1	62.7	33.2
200-210	11.9	51.2	36.9	4.6	63.2	32.3
210-220	5.7	55.0	39.3	4.3	66.4	29.4
220-230	6.4	53.6	40.3	5.9	64.8	29.3
230-240	7.0	53.7	39.4	6.8	63.5	29.6
240-250	11.5	48.5	40.0	5.5	64.2	30.3
250-260	9.6	51.8	38.6	7.2	61.8	31.1
260-270	12.5	48.0	39.5	6.8	61.3	31.8
270-280	9.7	51.3	39.0	5.5	63.0	31.5
280-290	9.1	51.6	39.3	3.6	63.2	33.2
290-300	10.7	47.6	41.7	5.9	62.2	31.9
300-310	13.5	47.7	38.8			
310-320	12.9	48.6	38.5			
320-330	10.2	51.8	37.8			
330-340	8.8	51.2	38.0			
340-350	8.2	53.8	38.0			
350-360	9.5	53.9	36.6			
360-370	9.8	52.9	37.3			
370-380	14.5	50.2	35.3			
380-390	19.7	44.9	35.4			
390-400	24.0	41.7	34.4			